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The status of the flat-tailed horned lizard (*Phrynosoma mcallii*) at nine sites in Imperial and Riverside Counties, California

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Abstract

Eight 210 x 210 m plots (4.41 ha) were established in Imperial and Riverside Counties, California, during April 1978. Each of these plots (10-17) was staked in a 15 x 15 rectilinear grid. Another study area was established in Section 30 on East Mesa during early August 1978. Soils in Plots 10-17 were inspected and mapped by Lanny Lund during the summer. Numbers and kinds of annual and perennial plants in these plots were determined from counts in 100 small (0.10 or 0.25 m^2) quadrats (annuals) or 13 belt transects 50 x 4 m (perennials). Cover by perennials was estimated from measurements of shrubs and trees. During May and June, counts of active nests of 13 species of ants were made in Plots 10-17, and kinds of ants in scats of horned lizards (Phrynosoma mcallii) were identified by Roy Snelling. Horned lizards and scats of horned lizards were enumerated in all 9 plots and 1-mile transects were walked across apparently unpopulated or sparsely populated areas. Conventional registries of all captured and recaptured horned lizards were maintained. Counts of fringe-toed lizards were made in all plots, and 31 of these lizards were marked and released in one plot in Riverside County.

Soils in all areas were sandy and generally similar, although some plots (e.g., 10, 16, and 17) were more heterogeneous than others. All soils were alkaline (pH 7.4-8.4) and mildly to strongly effervescent. Active dune sand occurred in Plot 10. Except for Plot 10, which was dominated by palo verde (Cercidium floridum), plots supported typical mixtures of desert shrubs. Creosotebush (Larrea tridentata) and bursage (Ambrosia dumosa) had high importance values in all plots, and

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saltbush (Atriplex canescens) was important in Plots 14 and 17, while mesquite (Prosopis glandulosa) was a co-dominant with Larrea in Plot 13. Numbers of perennial species recorded ranged from 2 (Plot 12) to 8 (Plot 10), with diversities ($\hat{H}'$) as low as 0.25 (Plots 12, 13) and as high as 0.55–0.57 (Plots 10 and 15). Aggregate perennial density was high (>1000 plants/ha) in Plots 10, 15, and 16, but generally low (≤300/ha) in other plots. Aggregate cover ranged from <10% (Plots 11, 14, 15 and 17) to 45% in Plot 10. Forty-four kinds of annual plants were identified in Plots 10–17, and four small perennial herbs were included in quadrat counts. Only Plantago insularis and Camissonia claviformis were recorded in all 8 plots. From 10 (Plot 16) to 22 species (Plot 17) were recorded in individual plots, and aggregate densities ranged from over 1300/m^2 (Plot 15) to 13/m^2 in Plot 10. Deversities of annual plants were inversely correlated with densities, because higher densities generally represented the numerical dominance of one or a few species. Thirteen different kinds of ants were collected in Plots 10–17, and a few additional species were present in scats. Ants made up >97% of all identified insects in 16 scats. Harvester ants (Veromessor pergandei, Pogonomyrmex californicus and P. magnacantha composed 75%, and a fourth species (Conomyrma insana) 16%, of all ants in scats. Horned lizards were captured in only 4 (14, 15, 16 and 17) of 9 plots examined, but scats were observed along 1-mile transects walked in the vicinity of some of the other plots. Numbers of horned lizards observed per man-hour (irrespective of identity) ranged from 0.12 (Plot 14) to 1.15 (Plot 15). Absolute numbers of different lizards marked ranged from 3 (Plot 14) to 35 (Plot 15). The density of P. mcallii

in Plot 15 was estimated by capture-recapture analysis at around 6-8/ha. P. mcallii is similar to P. platyrhinos in terms of sex ratio (1:1), age at maturity (20 months), and ability to lay more than one clutch of eggs in favorable years. Home ranges of 11 horned lizards estimated from convex polygons and corrected for sample size bias ranged from 0.04-1.40 ha for 6 females and 0.42-1.92 ha for 5 males. Typical home range extents in Plot 15 were judged to be about 0.5 ha for females and 1.3 ha for males. Fringe-toed lizards (Uma notata) were either absent or uncommon in all Imperial County plots, but U. inornata was common in Plot 17 in Riverside County. Density here was estimated at around 10-11/ha.

Indexes of abundance of P. mcallii in Plots 10-17 (based on numbers of lizards observed per man-hour) were uncorrelated with at least 6 of 9 independent variables based on attributes of annual and perennial vegetation and numbers of nests of ants consumed by horned lizards. Horned lizard abundances were positively correlated with aggregate density of annuals and inversely correlated with annual diversity. Multiple regression analyses analysis led to a 3-term equation predicting lizard abundance (Y) from 1978 sampling data:

$$Y = 35.6 - 134.24_1 + 130\hat{H}' + 0.92A$$

with A_1 the diversity of annuals, $\hat{H}'$ the diversity of perennials, and A the number of active nests of harvester ants. This equation accounted 92% of the observed variation in the dependent variable.

Introduction

The flat-tailed horned lizard (Phyrnosoma mcallii)[1] occurs in desert areas of southeastern California, southwestern Arizona, and adjoining portions of Sonora and Baja California Norte, Mexico. We do not know all factors influencing the local distribution and abundance of this species, nor why it often exhibits apparently low densities in areas where it occurs. With regard to the relative abundance of lizards in San Diego County, Klauber (1939) commented: "Probably the rarest... {is} ...Phrynosoma m'callii on the desert." Norris (1949) observed that near Palm Springs the capture of Phrynosoma mcallii "was not a common occurrence," and that "If two specimens were taken in a day...collecting was good."

Partly because of these observations and partly because of increasing use and development of desert areas in Riverside and Imperial Counties, concern as to the status of P. mcallii was expressed by Stewart (1971) and in 1973 by staff of the Museum of Vertebrate Zoology in Berkeley. Similar views were expressed through the Planning Commission of Riverside County, and the Office of Endangered Species of the U. S. Fish and Wildlife Service responded by designating P. mcallii a species whose status should be thoroughly reviewed. The problem has now become more urgent because of prospective construction of geothermal power plants on East Mesa in Imperial County.

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[1] We follow the nomenclature recommended by Funk in his preparation for the Catalog of North American Amphibians and Reptiles

In April of 1978 the Bureau of Land Management established a contract with the University of California to examine the status of P. mcallii in various parts of Imperial and Riverside Counties. The purpose of this work was to determine the presence or absence, and the relative abundance of P. mcallii in eight areas designated by the Bureau of Land Management, and to gather information on structure of populations and movements by individuals. The work also involved characterizations of soils, conventional assessments of perennial and annual vegetation, and counts and identifications of ant colonies at each of the sites. Finally, the contract required that the relative abundance of Uma notata (Imperial County) and U. inornata (Riverside County) be recorded when these species were present. Most of this work was carried out between April and July 1978.

During the spring of 1978 we learned that Republic Geothermal, Inc., was planning the construction of a 10 Mw geothermal power plant on East Mesa. The plan of our research was then expanded to include an assessment of the status of P. mcallii in Section 30 where the power plant is to be built. This work was done between August 4-6, 1978.

The purpose of this report is to review our findings and to discuss the apparent status of P. mcallii in terms of the general ecological attributes of the various areas examined.

Procedures

A. Establishment of study areas

During April 1978, eight study areas were established in sections prescribed by the Bureau of Land Management. In August 1978, a ninth area was selected in Section 30 on East Mesa in an area leased by Republic Geothermal, Incorporated (Fig. 1).

Each of the first eight areas was inspected, and a plot laid out in habitat fitting the Bureau of Land Management's description. Plot 10 (described as "microphyll woodland") was the only area posing a problem in site selection. The wooded area (primarily palo verde) lay between extensive dunes (to the west) and typical desert scrub (Larrea-Ambrosia) to the east. The situation was complicated by heavy flooding earlier in the spring. There had been large ponds at this time and evaporation of ponds left caked and cracked areas of sand and silt. Some of these areas had to be included in our plot. Appendix 1 gives descriptions and locations of all study plots.

All sites were located at least 1/4-mile from major paved roads, though some adjoined little-used dirt or gravel roads. In plots 10-17 15-m rectilinear grids were laid out 210 m on a side (4.41 ha, 10.9 ac). Each grid intersection was marked with a numbered wooden stake, identifying the point in terms of X-Y coordinates. Stakes were positioned using a transit on a tripod and a 50-m steel tape. Figs. 2-9 illustrate general aspects of Plots 10-17.

B. Soils

The distribution of soils within each of plots 10-17 was determined by walking transects across plots. Surface configuration, surface textures and colors of surface horizons were the principle characteristics used for the first approximation of local soil variability. After determining the complexity of soils, type locations were described and soil boundaries plotted. Soils of Plots 12 and 14 were uniform and only one mapping unit was needed. In other plots (e.g., 16 and 17) soils were variable and a number of mapping units were necessary. All mapping units may include similar and dissimilar soils, but units are named for the dominant soil present within the delineations.

Type locations were selected to represent a mapping unit at each plot. Holes were dug to expose profiles for descriptions. Soil descriptions were made using standard terminology of the USDA-SCS Soil Conservation Service (Soil Survey Staff, 1975). Colors were determined using standard Munsell color charts. Textures were determined by feel. The presence of carbonates was determined using 1N HCl, and pH was determined using indicator dyes. After field work was completed, soils were correlated, series names were assigned to mapping units, and all series were classified.

C. Counts and measurements of perennial shrubs

Perennial plants were counted and measured in thirteen 50 x 4 m transects in each of eight plots. These transects were centered on the north-south grid lines and their positions were determined by a procedure based on random numbers. Shrub canopies were measured along two

perpendicular axes (d and f). Mean diameters, $\bar{D}$ (m), of shrub species were computed for each plot using canopy measurements. For the i_{th} species, with measurements of n_i individuals:

$$\bar{D} = (\Sigma d_i + \Sigma f_i)/2n_i \quad (1)$$

Plot densities were estimated from the number of plants counted in all transects. Extents of sampled areas were adjusted in terms of the mean diameters of each species. Hence, the adjusted area sampled for the i_{th} species, A_i (m^2), with 13 transects counted, was computed as:

$$A_i = 13(50 + D_i)\ (4 + D_i)\ m^2 \quad (2)$$

The density of the i_{th} species, D_i, was estimated from the number of individuals counted in all transects, n_i, and the sampled area A_i:

$$D_i = n_i/A_i \text{ per } m^2 \quad (3)$$

The relative density of the i_{th} species, DR_i, was computed as:

$$DR_i = 100\ D_i/\Sigma D \quad (4)$$

The frequency of the i_{th} species, F_i, was calculated by dividing the number of transects in which the i_{th} species occurred by 13 and multiplying by 100. The relative frequency of the i_{th} species, RF_i, was:

$$RF_i = 100\ F_i/\ \Sigma\ F \quad (5)$$

Coverage was estimated by assuming shrubs to have elliptical canopies. Hence, the coverage of a shrub with measurements of 0.8 and 0.6 was

π (0.4) (0.3)m^2, or 0.38 m^2. The mean coverage (m^2) of one individual of the i_{th} species, based on measurements of n_i shrubs was:

$$MC_i = (\Sigma\pi\ d_i f_i)/4\ n_i \tag{6}$$

Coverage of the i_{th} species, C_i (%), with N_i individuals counted, was simply:

$$C_i = 100\ MC_i N_i / A_i \tag{7}$$

Total coverage, CT(%) was the sum of the coverages of all species. Relative coverage of the i_{th} species, CR_i, was taken as 100 CR_i/CT.

Importance value indexes were computed for each species at each site (Cain and Castro 1959: 211). The importance value index of the i_{th} species, IV_i, was computed as:

$$IV_i = RF_i + CR_i + DR_i \tag{8}$$

Shrub species diversity was estimated as $\hat{H}'$, as defined by Pielou (1969) for each plot. The estimates of $\hat{H}'$ (assuming that the samples were drawn from infinite populations) depended on the various estimates of relative abundance, $\hat{P}_i$, obtained from the density estimates, with $\Sigma\ \hat{P}_i = 1$. Then:

$$\hat{H}' = -\Sigma\hat{P}_i \log \hat{P}_i \tag{9}$$

D. Counts of annual plants

Densities of annual plants were estimated from counts in 100 randomly dispersed quadrats at each of eight plots. Two sizes of quadrats were used (0.1 m^2 and 0.25 m^2) depending on the species being counted. Exceptionally abundant species (e.g., Plantago insularis) were counted in 0.1 m^2 quadrats; less common species in 0.25 m^2 quadrats. Densities were estimated by dividing the total number of plants of a given species counted by the total area surveyed (either 10 or 25 m^2).

Percent aggregate cover of all annual plants was visually estimated on the six-point Braun-Blanquet (1932) scale:

Cover class	Estimated range of cover (%)	Midpoint of range (%)
0	<1	0.5
1	1 - 5	2.5
2	6 - 25	15.0
3	26 - 50	37.5
4	51 - 75	62.5
5	76 - 100	87.5

Cover by some of the more common individual species was also estimated visually. Diversity of annual plants in eight plots was estimated as Δ_1 of Hurlbert (1971).

E. Ants

In each of Plots 10-17 ten 15 x 15 m quadrats were randomly selected for counts of active ant colonies. Quadrats were inspected early in the morning because ant activity decreased sharply when soil temperatures

reached 38° C. According to our observations only Pogonomyrmex californicus remained active throughout the day. In addition to counts of active colonies, ants were collected from colonies and in other portions of plots. These ants were preserved in alcohol. Scats of Phyrnosoma mcallii were usually composed almost exclusively of ant parts. Some scats were collected and preserved. All ants and ant remains (in scats) were given to Roy Snelling at the Los Angeles County Museum of Natural History for identification. Diversities of active ant nests counted in quadrats were computed as Δ_1 of Hurlbert (1971).

F. Lizards

Work with lizards began on May 1 in Plot 12 and continued through June 28. The general plan was to spend five days working in each of Plots 10-17. Plots were systematically examined by two or three men walking 7.5 m apart and guided by stakes. These inspections were carried out early in the morning or late in the afternoon, when P. mcallii was active. Some of the plots were apparently unoccupied or sparsely inhabited by horned lizards. When no horned lizards were observed in the course of two days of work the mode of investigation was changed to walking 1-mile transects across the entire section originally specified by the Bureau of Land Management.

On May 5, 49 can traps were buried in the southwest quarter of Plot 12, and 51 traps were buried on the east side of Plot 11 (along lines 15 m apart). These cans were inspected periodically until May 15. During this time Dipsosaurus dorsalis, Uta stansburiana, Coleonyx variegatus, Cnemidophorus tigris, Callisaurus draconoides and Chionactis

occipitalis were trapped in varying numbers. No horned lizards were captured. Because these traps did not enhance our sampling effort they were filled with sand and abandoned on May 15.

Scats of P. mcallii were of definitive size and appearance. Most scats were about 15-20 mm long, usually black, and often lustrous because of the closely packed remains of ants composing them. Scats were counted in twenty of the 196 15 x 15 m quadrats composing each of plots 10-17 and in twenty quadrats distributed over Section 30 on East Mesa. Scats were also counted along 1-mile transects across sections.

When a horned lizard was first observed in a plot it was captured and its cloacal temperature recorded. Ground temperatures and air temperatures (45 cm in the shade) were also recorded. Each lizard was placed in a numbered cloth bag and the coordinates of its point of capture recorded. Processing lizards included marking animals with a unique combination of clipped toes, applying a temporary identifying mark with quick-drying paint, measuring snout-vent length and body weight, and determining reproductive states of females by palpation. Animals were returned to points of capture and released after processing. All of these procedures have been described in more detail by Medica et al. (1971). Not all marked horned lizards were recaptured if observed within a few days of first capture (the paint marks permitted the recognition of lizards from a distance). The locations of animals observed but not recaptured were recorded.

As plots were inspected records were kept of numbers of Uma notata or U. inornata observed, as well as numbers of other species of lizards. Uma inornata was so abundant in Plot 17 that a number of individuals

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were captured, measured, marked and released between June 23 and 25.

Additional field work was carried out in Plot 18 during early August, and in Plot 15 in early August and on September 21.

Capture-recapture data pertaining to P. mcallii in Plot 15 and Uma inornata in Plot 17 were analyzed as a chain of samples (Schumacher and Eschmeyer 1943). Home range estimates were derived for lizards captured three or more times in Plot 15. Capture loci were mapped and outermost points connected to form convex polygons. The vertices of these polygons were ordered counterclockwise and areas computed as recommended by Jennrich and Turner (1969):

$$\text{Area} = 1/2 \sum_{i=1}^{n} (x_i y_{i+1} - y_i) \qquad (10)$$

with (x_i, y_i) the coordinates of the i_{th} ordered capture point from a total of n points. Home range estimates were adjusted for sample size bias (Jennrich and Turner 1969, Table 2).

Results

A. Soils

In general, soils are quite similar in the various plots. This is to be expected because parent materials are recent deposits and soil formation (profile differentiation) proceeds slowly in desert environments. Because of the hot, dry climate and paucity of vegetation, soil differences within and between plots are mainly determined by mode of deposition of parent materials and subsequent reworking by wind and water.

Profile descriptions for all type locations are given in Appendixes 2-9. Table 1 summarizes some general features of type locations and Table 2 lists mapping units and symbols for soil types. Figs. 10-15 illustrate distributions of soil types in Plots 10, 11, 13, 15, 16 and 17. Soils were uniform in Plots 12 and 14.

The only plot with active sand dunes within the plot boundary was Plot 10. However, Plots 10, 12, 13, 16 and 17 had stabilized dunes composed of coarse soil materials. Relatively flat sandy deposits (alluvial rather than wind deposited) occurred in Plots 11, 14 and 15.

Only a few areas in Plots 10, 11 and 16 were not composed of sands. In Plots 10 and 16 the non-sandy material appeared to have been sorted by water and deposited in washes and depressions. In Plot 11 a layer of heavier textured material was present on a subsurface layer, and subsoil materials higher in clay content were scattered throughout the area (mapping symbol AnB).

Most of the soil materials were loose and easily disturbed. Exceptions to this were as follows: Plot 10 -- silty clay loam surface of

RtB; Plot 11 -- clay subsoil of GlA; Plot 16 -- subsoil of AnB and surface areas of RtB; and Plot 17 -- mapping unit RoC and Ro portion of Rn-Ro complex. These areas could affect the digging activities of animals.

Only three plots had significant amounts of coarse materials greater than 2 mm (gravel). A desert pavement occurred in Plots 14 and 15 and calcium carbonate nodules were present on the surface and in some subsoils in Plot 11.

In summary, variability of soils within and between plots was limited mainly to texture, consistence and surface relief. All of the soils were very low in organic matter and mildly to moderately alkaline. With few exceptions all soils were calcareous.

B. Perennial plants

Sampling attributes of perennial vegetation in eight plots are set forth in detail in Appendixes 10-17. Table 3 abstracts salient aspects of these data for all species with importance values exceeding 5. Table 4 gives further syntheses of sampling data, including information on aggregate density, coverage and diversity.

Plot 10 (the microphyll woodland) differed conspicuously from all others in the high densities of palo verde (Cercidium floridum) and Stillingia linearifolia, and the subordination of typical desert shrubs like creosotebush (Larrea tridentata) and bursage (Ambrosia dumosa). Diversity and aggregate cover were high. Plots 11-14 were all characterized by creosotebush as a dominant or co-dominant, low aggregate desities (200-300 shrubs/ha), low cover (usually less than 15%), and

low diversities (≤ 0.40). Coverage was high in Plot 13 (29%) because of the presence of mesquite (Prosopis glandulosa). Plots 15, 16 and 17 all exhibited distinctive attributes, including the subordination of creosotebush (Plots 15 and 17), high densities (Plots 15 and 16), low cover, and high diversities (Plots 15 and 17).

C. Annual plants

The spring of 1978 was notable for the abundance and growth of annual plants. The general aspect of many of our plots was unusual because of the carpets of winter annuals. Table 5 lists species of annual plants recorded in each of eight plots. Four perennial herbs are included with the annuals (Aristida californica, Coldenia plicata, Dalea mollis, and Hesperocallis undulata). Only Camissonia claviformis and Plantago insularis were registered in all plots. Other widespread species were Cryptantha angustifolia (7 plots), Baileya pauciradiata and Schismus arabicus (6 plots).

Indexes of similarity (S) were computed for all pairs of plots, based on rosters of annual species recorded:

$$S = 2C/(A + B) \quad (11)$$

with A the number of species in the first plot, B the number of species in the second plot, and C the number of common species. The matrix of indexes is set forth in Table 6. Plots 10, 16, and 17 exhibited generally low similarities with other plots. Plot 10 differed in general quality from all others because of the relative paucity of annuals beneath trees and in areas flooded earlier in the spring.

Plots 11-15 displayed somewhat higher affinities, and the highest indexes (>0.5) were generally those involving Plots 11, 12, 13 and 14. This is reasonable given the general locations of these plots and the similarities of their perennial vegetation.

Appendixes 18-25 give estimated densities of all sampled species of annuals in eight plots, together with cover indexes for those few species with estimated coverages exceeding 5%. Densities are scaled up from counts in 100 quadrats in each plot. Quadrats were usually 0.25 m^2, but a few species were counted in 0.1 m^2 quadrats. Table 7 summarizes salient features of annual vegetation in eight plots.

D. Ants

The following discussion of ants is based on comments and other information given by Roy Snelling of the Los Angeles County Museum of Natural History. Table 8 indicates kinds of ants collected in each of nine areas, and gives numbers of active nests (by species) counted in ten 15 x 15 m quadrats in Plots 10-17.

Table 8 is not a complete list of species present at any of the sites. We did not collect any strictly nocturnal species. In Snelling's view we probably collected about half the species present in the areas. Snelling (in litt.) has suggested that "...there should be another two or three species of Pheidole...another three or four Myrmecocystus... and one or two species of Campanotus." It is fair to infer that Pogonomyrmex californicus, P. magnacanthus, Veromessor pergandei and Conomyrma insana are generally distributed species in the areas where we worked, while Acromyrmex versicolor, Pheidole barbata and Pogonomyrmex

maricopa appear to be less widely distributed. The apparent absence of P. californicus from Plot 15 may be real for, according to Snelling, P. maricopa sometimes replaces P. californicus. Although no Veromessor pergandei were collected in Plot 16, this species almost certainly occurs there. Acromyrmex versicolor may have rather localized distributions; according to Snelling it is closely associated with ironwood trees in sandy washes.

Table 9 gives diversity estimates for eight plots based on numbers and kinds of active nests counted in quadrats. Except for Plot 15, most of the estimates of Δ_1 are of comparable magnitude (0.6-0.8). In Plot 15 about 85% of the nests counted were of Conomyrma insana. It is not clear how accurately counts of nests in 10 quadrats (~5% of the area of a plot) reflect true nest abundances. We counted all of the active nests of Veromessor pergandei (38) in Plot 15. These were distributed fairly evenly over the entire plot without obvious clumping. We may have counted multiple entrances of the same nest as different nests because, according to Snelling, Veromessor nests often have a number of widely separated entrances. The quadrat counts of Veromessor nests (3) imply about 50% more nests in the area (~60) than were actually present. The data in Table 8 must be gauged in this light.

Sixteen scats of P. mcallii have been examined by Snelling. Five scats contained only ant remains. Eleven contained remains of 98 insects other than ants: small hymenopterans, tenebrionid beetles, weevils, membracids, small bugs, etc. Over 4200 ant heads in the 16 scats were identified by Snelling (Table 10). One scat contained over 1200 head capsules and remains of several hundred capsules in a scat were not

unusual. Four species of ants (Veromessor pergandei, Pogonomyrmex californicus, P. magnacantha and Conomyrma insana make up 91% of ants in these scats, and these species were represented in from 69 to 94% of the scats examined. Other kinds of ants made up ≤4% of the total and generally exhibited frequencies of ≤25%.

Snelling is continuing to examine the contents of other scats and contents of stomachs of horned lizards collected dead on roads, so more information of this nature will be available. It is unlikely that further counts will change the general pattern exhibited in Table 10. Further work will involve comparisons of ants consumed with apparent abundances of various species in the plots.

E. Horned lizards

The flat-tailed horned lizard is shown in Fig. 16. Basic observations of lizards and scats of P. mcallii in nine plots are set forth in Table 11. This table expresses abundances of horned lizards as numbers of different lizards registered (col. 4) and as numbers of lizards observed per man-hour regardless of their identity (col. 5). Hence, column 4 divided by total man-hours does not necessarily equal column 5. Other lizards treated in Table 11 include Uta stansburiana, Cnemidophorus tigris, Callisaurus draconoides, Dipsosaurus dorsalis, Crotaphytus wislizenii, Urosaurus graciosus and Sceloporus magister. Only the first four of these were common. Data pertaining to species of Uma are treated subsequently. Table 11 is based on inspections of plots by two or three men walking back and forth across plots guided by grid markers. Counts of horned lizards and scats along 1-mile transects are summarized in Table 12.

The information summarized in Tables 11 and 12 clearly indicates that Plot 15 differs from other areas examined in terms of numbers of horned lizards. Not only were lizards fairly common within the sampled area, but around a dozen lizards were observed between the highway and the plot between May 1 and 16. Plots 14, 16 and 17 support populations of horned lizards, but at apparently lower densities than Plot 15. The sites on East Mesa (11, 12, 13 and 18) were generally comparable in evidencing either an absence of horned lizards or sparse populations.

Table 13 summarizes sizes and weights of horned lizards registered in Plot 15 between May and September 1978, and gives reproductive data for adult females. We estimated ages of animals registered during May, but ages of adults could not be determined later in the summer. We believe that two cluches of eggs were laid by most females in 1978. Young from the first clutch hatched during July. Young from the second clutch probably hatched during August and early September (see Number 55, Table 13). In addition to this small hatchling another was found on the highway on September 20. It was 30 mm long and weighed only 1.6 g. Table 14 summarizes comparable data for horned lizards registered in Plots 14, 16 and 17.

Of 50 adult horned lizards registered 29 were males and 21 females. Wilbur Mayhew's field notes referred to sex ratios of samples collected along the highway near Glamis and of a group of lizards used in a laboratory experiment. Of 65 lizards, 29 were males and 36 females. Neither our findings nor Mayhew's represent significant departures from an expected sex ratio of 1:1. We cannot be sure of the ages of all lizards listed in Tables 13 and 14, but assuming yearling males to range

from 9-11 g and yearling females from 8-12 g (among the May lizards in Plot 15) the mean weight of five young males was 9.8 g, that of six young females 9.3 g. Mean weights of 22 other males and 15 other females were 16.0 and 17.8 g, respectively. Female P. mcallii are probably not sexually mature until an age of around 21 months (e.g., see Numbers 12, 14, 17 and 26, Table 13). Mayhew's notes refer to numbers of eggs laid by captive specimens and a clutch size of 5 was common. Tanner and Krogh (1973) reported a mean clutch size of 6.8 among 20 female P. platyrhinos. As indicated above, P. mcallii may lay more than one clutch of eggs in favorable years. In terms of population structure, age at maturity, and reproductive potential, P. mcallii is similar to P. platyrhinos in southern Nevada (Medica et al. 1973).

The only recaptured P. mcallii occupied Plot 15. Capture-recapture data for May are given in Table 15. These data may be arranged for capture-recapture analysis as indicated in Table 16. The population estimate is 11,144/413 or ca. 27. Given a study area of 4.41 ha, the estimated density of P. mcallii in Plot 15 was around 6.1/ha. On the evening of June 26 and the morning of June 27 Plot 15 was reexamined in order to see if horned lizards were still active at this time of the year. On June 26 two new and four previously marked lizards were taken. If these data are combined with the earlier capture-recapture data (from May) the number of lizards in Plot 15 would be estimated as around 34.2, with a corresponding density of 7.8/ha.

Loci for horned lizards captured more than once in Plot 15 are summarized in Appendix 26. Distances between successive capture points ranged from as little as 1.1 m (2-6 days) to 104 m (7 days). Average

duration between the six longest movements (>60 m) was about 45 days (0.5-128 days).

Table 17 gives computed sizes of convex polygons based on three or more capture loci, sample size correction factors, and adjusted home range estimates for 11 horned lizards. Fig. 17 illustrates six representative polygons. Most of the polygons were based on 3-4 captures, and even with sample size bias corrections we view these findings with some reservation. Nevertheless, the contrast between males and females is striking. All but one of the six females had estimated home ranges of ≤0.5 ha; all but one of the five males had estimated ranges exceeding 1 ha. The three small home ranges of females 12, 26 and 28 (<0.12 ha) are underestimates because the three capture loci for each of these individuals were almost in a line. Based on data for five males and three females we judge that home ranges are around 1.3 ha for males and 0.5 ha for females. These are fairly large home ranges for lizards of this size. Turner et al. (1969) analyzed home ranges of terrestrial lizards and derived the following relationship between home range size (m^2) and body weight (W, g):

$$A = 171.4W^{0.95} \quad (12)$$

All species reviewed by these authors with body weights from 15-20 g had estimated home ranges of less than 1 ha. Equation 12 predicts a home range of around 0.25 ha for P. mcallii (based on a body weight of 17 g).

Forty-one measurements of P. mcallii cloacal temperatures (21 females, 20 males) were made between May 7 and June 26, 1978, with accompanying

records of air temperatures (45 cm) and soil surface temperatures. The lizards ranged from 52 to 81 mm in snout-vent length and from 8 to 26 g in live body weight. Measured body temperatures ranged from 27.4 to 41.0° C, with a mean of 35.6° C. The maximum and minimum associated soil temperatures recorded were 47.8 and 26.4° C; the earliest time of recording was 0715, the latest 1935. Multiple regression analyses showed that sex and body size (whether expressed as length or weight) had no statistically significant effect on measured body temperatures. The following expression accounted for 79% of the observed variation in body temperatures (T_B):

$$T_B = 0.33T_s + 0.36T_a - 0.0019H + 14.7 \qquad (13)$$

with T_s the soil temperature, T_a the air temperature and H the time of day on a 24-hour system.

F. Fringe-toed lizards

Uma notata was either absent or uncommon in all of the Imperial County plots, and exhibited its highest apparent density in that part of Plot 10 composed of sand dunes. On the other hand, U. inornata was common near Bermuda Dunes in Riverside County. Table 18 summarizes total man-hours spent in formal inspections of eight plots, numbers of Uma counted, and numbers of Uma observed per man-hour of effort.

Table 19 summarizes data pertaining to 31 Uma inornata captured and marked in Plot 17 during late June. We do not know the ages of these lizards, although the smallest females (10-11 g) may have been about 10 months of age and sexually immature. The mean body weight of

15 females was 14.5 g, that of 16 males 24.4 g, but the age compositions of these two subsamples may be different. The regression equations (r = 0.92-0.97) for body weight (g) on snout-vent length (mm) were:

$$W_m = 0.766L - 45.0 \quad (14)$$

$$W_f = 0.543L - 26.4 \quad (15)$$

The standard errors of the regression coefficients were aroung 0.06. When all 31 individuals were combined (r = 0.97):

$$W = 0.703L - 39.0 \quad (16)$$

These equations are obviously only applicable to adult lizards and the relationship apparently flattens among smaller individuals.

Capture-recapture data for U. inornata are given in Table 20. From these data we estimate the abundance of Uma in this plot as 14,415/310, or 46.7 (10.6/ha).

G. General analysis

To what extent can we understand the apparent differences in numbers of P. mcallii in the original eight plots (10-17) in terms of various environmental variables assessed? We examined this question by stepwise multiple regression analysis, using indexes of lizard abundance based on numbers of P. mcallii observed per man-hour as dependent variables (Table 11). Dependent variables were the values in Table 11 multiplied by 100, except that if this product was zero it was set equal to one. The independent variables were 1) aggregate perennial density, 2) aggregate perennial cover, 3) diversity of perennials (all Table 4), 4) number of annual species, 5) cover by annuals, 6) aggregate density of annuals, 7) diversity of annuals (all Table 7), 8) numbers of active nests of harvester ants counted, and 9) numbers of active nests of harvester ants and Conomyrma insana (both Table 8).

The correlation matrix is set forth in Table 21. This table shows the dependent variable to be directly correlated with aggregate density of annuals and inversely correlated with annual diversity, but no other strong correlations emerge. It should be noted that annual density and diversity are themselves strongly correlated ($r = -0.93$).

The multiple regression analysis involved more independent variables (9) than cases (8) so we may expect high R^2 values if enough variables enter the equation. We include the complete summary table (Table 22), but are not prepared to

argue that this analysis has any biological significance. If we restrict ourselves to just the first three variables entered, the equation estimating abundance indexes of horned lizard is:

$$Y = 35.6 - 134.2\Delta_1 + 130.0\hat{H}' + 0.92\underline{A} \qquad (17)$$

where $\underline{A}$ is the count of active harvester ant nests. Table 23 contrasts the actual indexes of abundance (from Table 11) and values predicted by Equation 17.

Discussion

The most important questions concerning Phrynosoma mcallii concern the present distribution and abundance of the species, how these attributes may be changing, and what steps should be taken to protect remaining optimal habitats. According to Berry (pers. comm.) about 96% of the estimated geographical range of this species is committed to one or another human pursuits, any of which could be deleterious to the well-being of this species. Unfortunately, optimal habitats are not obviously apparent. We know something of the general habitat requirements of the species, but nothing about factors influencing relative abundance.

Lowe (1964) described the occurrence of P. mcallii in Arizona as on "fine sandy soils, not gravelly or rocky, with or without scant vegetation; occurs commonly with Uma notata on lower parts of loose wind-blown dines." Funk, in his preparation for the Catalog of North American Amphibians and Reptiles, observed: "This is generally true of the habitat outside of Arizona, but occasionally in southern California specimens may be found on gravelly sites near sandy areas." Our observations in Imperial County bear out Funk's comments.

As indicated earlier, P. mcallii is often rare in areas where it occurs (Klauber 1939). Pianka and Parker (1975) commented that "horned lizards in general- are seldom very abundant and, in fact, are often rather uncommon lizards."

On the other hand, Mayhew's continued investigations of a 7-mile stretch of road between the Highline and Coachella Canals east of Brawley showed that, at least in this area, P. mcallii sustained high numbers. Between the spring of 1961 and October 1964, Mayhew and his students collected 381 and found 121 dead Phrynosoma mcallii along this road. On May 26, 1963, Mayhew wrote in his notes: "I am convinced that P. m'calli is the most abundant reptilian species that occurs in the creosote bush scrub between the two canals."

Phrynosoma mcallii apparently feeds almost exclusively on ants, to a significantly greater degree than many other species of the genus (see Table 6, Pianka and Parker, 1975). Based on an examination of 106 stomachs Pianka and Parker reported that 97.2% of the prey items were ants. Snelling's counts of 4316 items in 16 scats of P. mcallii showed 4218 (97.7%) to be remains of ants. Whitford (in litt.) argued that the abundance of Phrynosoma cornutum in New Mexico is closely tied to the abundance of harvester ants (Pogonomyrmex desertorum, P. rugosus and P. californicus) on which it feeds. Whitford stated that he had "...been able to predict horned lizard abundance in two places, Carlsbad [New Mexico] and Prescott, Arizona....based on density of Pogonomyrmex colonies ..." even though P. cornutum eats more non-ants than P. mcallii (Table 6, Pianka and Parker, 1975). P. mcallii apparently feeds largely on harvester ants (Veromessor pergandei, Pogonomyrmex californicus and P. magnacantha). A smaller

ant, Conomyrma insana, also makes up a significant part of its diet. In a general way, then, both P. cornutum and P. mcallii utilize similar components of the ground-dwelling insect fauna. It is disappointing, then, that we found no positive correlations between numbers of nests of ants consumed and apparent numbers of P. mcallii. It is, of course, possible that we did not assess ant abundance intensively enough (see p. 15). While Plots 14, 15, and 17 had large numbers (>50) of active nests of harvester ants and Conomyrma insana, so did Plot 12. Furthermore, only six active nests were counted in Plot 16. Any future studies of ants should be focused on the 3-4 species now known to be the principal food of P. mcallii in Imperial County.

We also have difficulty in assessing the reality of some of the lizard-plant correlations. It is not clear whether the high density of Plantago insularis in Plot 15 (and the associated low diversity of annual plants) have any real biological relationship to the numbers of P. mcallii in that Plot. Total numbers of annual plants and relative abundance of various species vary from one year to the next. Were annual plants to be counted in plots in 1979 different results could obtain.

These points emphasize the difficulty we face today in attempting to determine the status of this lizard. Obviously there are significant local differences in numbers which are not easily explained. We suspect that year-to-year changes

in numbers occur--of the type we have documented for other iguanids in southern Nevada (e.g., see Turner 1977: 169-171). During the spring and summer of 1964 Mayhew commented in his notes that P. mcallii seemed less numerous than in previous years. Yet this was a generally poor time over most of the Mohave Desert. French et al. (1974), describing a long-term study of the dynamics and numbers of heteromyid rodents in southern Nevada, commented: "Studies were initiated... in August 1962, when populations were at high densities. Poor primary production the following two seasons resulted in a considerable decline in numbers of most species." This seems to have been true of Cnemidophorus tigris (Turner 1977: 172) in southern Nevada, but data for other lizards are lacking.

We may also be dealing with historical changes in abundance of Phrynosoma mcallii (i.e., long term trends rather than simple year-to-year fluctuations), but this possibility is exceedingly difficult to evaluate. There may be a chance to examine this question using the 7-mile stretch of highway Mayhew studied in 1961-64. Mayhew reported hours during the day when the road was inspected, and numbers of dead lizards found. He also computed the numbers of dead lizards per hour of effort for different seasons and different years. These efforts could be duplicated in 1979. We do not know how many people were involved in Mayhew's searches, and this road is used more heavily today than in

1961-64. If allowances for this last factor could be made, a useful comparison might be developed.

However, our most promising prospects lie in continued appraisals of contemporary habitats. Our position can be most significantly improved by finding more areas where horned lizards are abundant.

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Table 1. General attributes of soil types at eight plots in Imperial and Riverside Counties, California.

Plot	Mapping Unit	Classification	Hues	pH
10	Active dune sand	Mixed, hyperthermic Typic Torripsamment		
	Rositas loamy fine sand 0-75+ cm	Same	Light yellowish brown	7.7
	Rositas silty clay loam C1 (0-5 cm)	Same	Very pale brown	8.0
	C2 (5-75+ cm)		Light yellowish brown	7.6
11	Glamis gravelly silt loam	Hyperthermic, Typic Torrifluvent		
	C1 (0-33 cm)		Light yellowish brown	8.2
	IIC2 (33-45 cm)		Brown	8.3
	IIIC3 (45-100 cm)		Very pale brown	8.3
	Rositas sand	Mixed, hyperthermic, Typic Torripsamment		
	C1 (0-1 cm)		-	-
	C2 (1-75+ cm)		Light yellowish brown	8.3
12	Rositas fine sand	Same		
	C1 (0-3 cm)		"	8.0
	C2 (3-75+ cm)		"	8.2
13	Aco loamy fine sand	Hyperthermic, Typic Torriorthent		
	C1 (0-10 cm)		Reddish yellow	8.0
	C2 (10-100 cm)		"	8.0
	Rositas fine sand	Mixed, hyperthermic, Typic Torripsamment		
	C1 (0-10 cm)		Very pale brown	8.0
	C2 (10-100 cm)		"	8.0

Plot	Mapping Unit	Classification	Hues	pH
14	Rositas gravelly sand	Mixed, hyperthermic, Typic Torripsamment		
	C1 (1-30 cm)		Light yellowish brown	8.4
	C2 (30-75+ cm)		"	8.2
15	Rositas loamy coarse sand	Same		
	C1 (0-5 cm)		Pinkish white	8.1
	C2 (5-40 cm)		Brownish yellow	8.1
	C3 (40-75+ cm)		"	8.1
	Rositas coarse sand	Same	-	-
16	Antho loamy sand	Hyperthermic, Typic Torrifluvent		
	C1 (0-10 cm)		Pale brown	8.0
	C2 (10-75 cm)		"	8.2
	Rositas loamy fine sand	Mixed, hyperthermic, Typic Torripsamment		
	C1 (0-100 cm)		Light yellowish brown	8.0
	Rositas loamy coarse sand	Same		
	C1 (0-10 cm)		Light brown	8.0
	IIC2 (10-42 cm)		Light gray	8.2
	IIIC3 (42-100 cm)		"	8.2
	Rositas silty clay loam	Same	-	-
17	Rositas loamy sand (dune phase)	Same		
	C1 (0-5 cm)		Light gray	8.0
	C2 (5-100 cm)		"	7.6
	Rositas loamy sand (hard, eroded phase)	Same		
	C1 (0-5 cm)		"	8.0
	C2 (5-35 cm)		"	7.4
	C3 (35-100 cm)		"	7.6
	Rositas loamy sand, dune and eroded complex		-	-

Table 2. Soil mapping units and symbols for eight plots in Imperial and Riverside Counties, California.

Mapping Unit	Mapping Symbol
Aco loamy fine sand, 0-30% slopes	AcE
Antho loamy sand, 2-9% slopes, eroded	AnB
Active dune sand	Du
Glamis gravelly silt loam, 0-2% slopes	GlA
Rositas gravelly sand, 0-2% slopes	RaA
Rositas coarse sand, 0-2% slopes	RbA
Rositas sand, 0-5%, slopes	RcB
Rositas fine sand, 2-15% slopes, dune phase	RfD
Rositas loamy coarse sand, 0-5% slopes	RmB
Rositas loamy sand, 2-9% slopes, dune phase	RnC
Rositas loamy sand, 2-9% slopes, hard, eroded phase	RoC
Rositas loamy sand, 2-9% slopes, dune-eroded complex	Rn-Ro
Rositas loamy fine sand, 2-15% slopes, dune phase	RsD
Rositas silty clay loam, 0-5% slopes	RtB

Table 3. Attributes of perennial plants in eight plots in Imperial and Riverside Counties, California.

Plot	Species	Density (n/ha)	Coverage (%)	Frequency (%)	Importance value index
10	Cercidium floridum	290	37.9	100	136.9
	Stillingia linearifolia	534	1.7	92	78.9
	Larrea tridentata	36	2.6	92	31.9
	Ambrosia dumosa	91	0.1	38	18.7
	Hymenoclea salsola	44	0.3	46	16.4
	Chiloopsis linearis	10	2.1	15	9.5
11	Larrea tridentata	63	5.1	69	132.3
	Ambrosia dumosa	99	0.5	38	100.0
	Ephedra trifurca	18	3.1	38	67.7
12	Larrea tridentata	132	10.5	92	225.6
	Ambrosia dumosa	52	2.1	38	74.5
13	Larrea tridentata	234	17.8	100	188.8
	Prosopis glandulosa	52	11.3	100	104.6
	Ambrosia dumosa	8	0.1	8	6.6
14	Larrea tridentata	61	3.4	69	140.5
	Ambrosia dumosa	197	0.7	85	135.8
	Atriplex canescens	14	0.2	23	23.8
15	Ambrosia dumosa	374	2.1	85	89.4
	Dalea emoryi	335	2.6	69	88.7
	Larrea tridentata	401	1.3	100	84.3
	Coldenia palmeri	72	0.4	38	23.8
	Hymenoclea salsola	21	0.0	38	13.8
16	Larrea tridentata	294	5.0	100	142.3
	Atriplex canescens	246	1.7	100	101.7
	Prosopis glandulosa	28	3.4	23	48.2
	Ambrosia dumosa	8	0.0	15	7.8
17	Atriplex canescens	204	3.5	85	145.3
	Larrea tridentata	34	3.2	85	87.4
	Croton wigginsii	51	0.6	31	35.9
	Dalea emoryi	12	0.1	23	14.2
	Tamarix ramosissima	8	0.0	15	8.7
	Ambrosia dumosa	8	0.0	15	8.5

Table 4. Attributes of perennial vegetation in eight plots in Imperial and Riverside Counties, California.

Plot	Number of species encountered	Aggregate perennial density (n/ha)	Aggregate perennial cover (%)	Diversity ($\hat{H}'$)
10	8	1017	45.2	0.55
11	3	180	8.8	0.40
12	2	183	12.6	0.26
13	3	294	29.2	0.25
14	3	272	4.3	0.31
15	5	1203	6.5	0.57
16	4	2140	11.8	0.36
17	6	315	7.3	0.48

Table 5. Annual plants (and perennial herbs) recorded in eight plots in Imperial and Riverside Counties, California.

Species	Plots							
	10	11	12	13	14	15	16	17
Abronia villosa			x	x			x	x
Achyronychia cooperi		x	x	x	x	x		x
Amsinckia intermedia	x							
Aristida californica[1]		x	x		x	x		
Astragalus aridus							x	x
A. didymocarpus								x
Baileya pauciradiata	x		x	x		x	x	x
B. pleniradiata	x							
Bouteloua aristidoides			x					
Brandega bigelovii	x							
Brassica tournefortii	x		x					
Camissonia boothii						x		x
C. claviformis	x	x	x	x	x	x	x	x
Caulanthus cooperi				x				
C. lasiophyllus				x				
Chaenactis stevioides						x		
Chorizanthe brevicornu			x					x
C. rigida		x						
Coldenia plicata[1]		x	x					
Cryptantha angustifolia		x	x	x	x	x	x	x
C. costata	x					x	x	
C. micrantha	x	x	x	x	x			
Dalea mollis[1]		x		x		x		
Dicoria canescens								x
Dithyrea californica			x	x	x			
Eriogonum thomasii		x			x	x		x
Erodium cicutarium								x
Geraea canescens		x				x		x
Hesperocallis undulata[1]		x						

Table 5 (cont.)

Species	Plots 10	11	12	13	14	15	16	17
Langloisia schottii		x	x		x	x		x
Lepidium lasiocarpum	x			x				
Mentzelia albicaulis		x	x		x	x		
Nama demissum						x		x
Nicotiana clevelandii				x				
Oenothera deltoides	x		x				x	x
Oligomeris linifolia	x	x		x	x		x	
Palafoxia linearis		x	x		x			x
Pectocarya heterocarpa		x	x	x	x			
Perityle emoryi								x
Phacelia crenulata								x
P. pediculoides				x				
Plantago insularis	x	x	x	x	x	x	x	x
Schismus arabicus	x	x	x	x	x	x		
S. barbatus								x
Sonchus oleraceus	x	x	x		x			
Sphaeralcea orcuttii							x	
Stillingia spinulosa						x		
Streptanthella longirostra				x				

[1] perennial herb

Table 6. Indexes of similarity (based on species of annual plants) for all pairs of eight plots in Imperial and Riverside Counties, California.

Plots	Plots						
	11	12	13	14	15	16	17
10	0.36	0.47	0.44	0.41	0.32	0.50	0.17
11	-	0.67	0.49	0.82	0.51	0.28	0.40
12	-	-	0.53	0.74	0.49	0.40	0.49
13	-	-	-	0.55	0.40	0.43	0.31
14	-	-	-	-	0.56	0.32	0.39
15	-	-	-	-	-	0.37	0.53
16	-	-	-	-	-	-	0.45

Table 7. General attributes of annual floras in the spring of 1978 in eight plots in Imperial and Riverside Counties, California.

Plot	Numbers of annuals counted	Numbers of annual species recorded	Diversity (Δ_1)	Most abundant species	Aggregate density (n/m^2)	Aggregate cover index	Range in density of individual species (n/m^2)
10	330	15[1]	0.77	Brassica tournefortii, Schismus arabicus	13.2	3	0.04 - 4.9
11	1,911	19	0.69	Plantago insularis, S. arabicus, Camissonia claviformis.	135.0	3	0.04 - 66.1
12	6,008	21[2]	0.66	P. insularis, Cryptantha angustifolia, S. arabicus	514.6	4	0.04 - 256.0
13	1,733	18	0.70	C. angustifolia, S. arabicus	120.2	3	0.01 - 60.0
14	4,112	15	0.52	C. angustifolia, S. arabicus	164.5	3	0.04 - 110.7
15	13,472	17	0.02	P. insularis	1325.7	4	0.04 - 1311.4
16	2,360	10	0.66	C. costata, Oligomeris linifolia	94.4	4	0.01 - 47.1
17	1,174	22[3]	0.76	C. angustifolia, S. barbatus	47.0	2	0.01 - 19.8

[1] including an unidentified Sphaeralcea

[2] including an unidentified Chorizanthe

[3] including an unidentified Salsola

Table 8. Kinds of ants collected and numbers of active nests counted in ten 15 x 15 m quadrats in nine plots in Imperial and Riverside Counties, California. Figures in parentheses indicate the number of quadrats in which nests of a particular species were recorded. Asterisks indicate that a species was collected in the area but no nests were counted.

Species	Plots								
	10	11	12	13	14	15	16	17	18
Pogonomyrmex californicus	15 (6)	*	14 (8)	21 (8)	*		6 (4)	26 (10)	*
P. magnacanthus		1 (1)	7 (4)	5 (2)	4 (3)	2 (2)		2 (2)	*
P. maricopa						1 (1)			
Veromessor pergandei	1 (1)		9 (4)	3 (2)	13 (5)	3 (3)		14 (6)	*
Acromyrmex versicolor	1 (1)								
Pheidole barbata								1 (1)	
P. psammophila		1 (1)		16 (6)	19 (7)		1 (1)		*
Solenopsis xyloni		9 (4)	3 (3)	3 (2)		1 (1)	5 (3)		
Myrmecocystus kennedyi	3 (1)					*	1 (1)	*	
Conomyrma bicolor	27 (8)				8 (5)				*
C. insana	1 (1)	23 (5)	22 (6)	*	48 (10)	44 (10)		10 (5)	
Forelius foetidus	29 (3)	1 (1)						4 (4)	
F. pruinosus		5 (3)	*	1 (1)	2 (2)	1 (1)			
Number of species collected in plots	7	7	6	7	7	7	4	7	5
Mean frequency in quadrats (%)	30	25	50	35	53	30	23	47	

Table 9. Numbers of active nests counted, numbers of species and estimated diversity of ant nests in eight plots in Imperial and Riverside Counties, California.

Plot	Numbers of active nests in 10 quadrats	Numbers of species	Diversity (Δ_1)
10	77	7	0.83
11	40	6	0.62
12	55	5	0.74
13	49	6	0.71
14	94	6	0.68
15	52	6	0.28
16	13	4	0.68
17	57	6	0.71

Table 10. Kinds and numbers of ants in 16 scats of *Phrynosoma mcallii* collected in Imperial County, California.

Plot	Date	*Veromessor pergandei*	*Pogonomyrmex californicus*	*P. magnacanthus*	*Conomyrma insana*	*C. bicolor*	*Myrmecocystus kennedyi*	*M. flaviceps*	*M. yuma or tenuinodis*	*Solenopsis xyloni*	*Forelius pruinosus*	*Pheidole* spp.	Totals
10	5-23	454	376		362	35	2						1229
10	5-22	10	90	21	16		54						191
10	5-24	4	23										27
10	5-24	30	40	2	4		1		4				81
10	5-24	96	22	634	48			2	2	18			814
10	5-24		34	14									48
12	6-26		78	65			1			1	2		147
12	6-26	73	59	26	6								164
13				79									79
13	5-25	47	94	6	17			57		3			224
11?	5-2	37	9		3								49
13	5-25	50	27	50				16		3			146
14	6-5	59	30	129	37		29					4	288
14	6-5	3	16	198	8		57				11		293
14	6-5	1	6	18	7		24	1					57
15	5-8	163	8		179				10		11	10	381
Totals		1027	912	1242	687	35	168	76	16	17	24	14	4218
Percent of overall total		24	22	29	16	<1	4	2	<1	<1	<1	<1	
Frequencies (%)		81	94	75	69	6	44	25	19	25	19	13	

Table 11. Observations of lizards and counts of scats of Phrynosoma mcallii in nine plots in Imperial and Riverside Counties, California.

Plots	Total man-hours	Months	Numbers of different P. mcallii registered	Numbers of P. mcallii observed per man-hour	Numbers of other lizards observed per man-hour	Numbers of scats counted in twenty 15 x 15 m quadrats
10	26.85	May	0	0	2.9	0
11	16.75	May	0	0	4.4	0
12	20.75	May	0	0	4.9	0
13	37.40	May	0	0	5.2	0
14	33.33	June	3	0.12	5.7	0
15	53.40	May-June	31	1.14	2.0	68
	6.80	August	4	1.15	2.3	-
16	28.25	June	4	0.14	7.7	2
17	27.00	June	10	0.48	4.2	2
18	24.00	August	0	0	2.2	2

Table 12. Counts of Phrynosoma mcallii and scats along 1-mile transects across seven plots in Imperial County, California.

Plot	Month	Number of observers	Number of 1-mile transects	Number of horned lizards observed	Number of scats counted
10	May	3	4	0	10
11	June	2	4	0	0
12	June	2	4	0	2
13	May	3	4	0	0
14	June	3	4	2	5
15	Aug	3	2	2	145
18	Aug	3	10	0	37

Table 13. *Phrynosoma mcallii* in Plot 15, Imperial County, California. Asterisks indicate hatchling lizards.

Dates	Number	Sex	Snout-vent length (mm)	Weight (g)	Estimated age (months)	Reproductive condition
May 7-9	11	m	69	15	21	
	12	f	58	8	9	negative
	13	m	81	22	21+	
	14	f	75	22	21+	six 7-mm yolked follicles
	15	f	53	8	9	negative
	16	m	61	9	9	
	17	f	63	11	9	negative
	18	m	75	17	21	
	19	f	74	21	21+	five 12-mm yolked follicles
	21	f	75	18	21	1 egg (some laid?)
	22	m	66	15	21	
	23	f	60	9	9	negative
	24	m	76	15	21	
	25	m	74	17	21	
May 15-16	26	f	63	12	9	negative
	27	f	69	15	?	negative
	28	f	80	26	21+	eggs
	29	m	70	14	21	
	31	m	68	14	21	
	32	m	73	19	21	
	33	m	59	10	9	
	34	f	52	8	9	negative
	35	m	59	9	9	
	36	f	66	14	?	negative
	37	m	57	11	9	
May 10	40	m	59	10	9	
June 26-27	38	f	73	14		negative
	39	m	71	15		
	41	f	70	15		negative
	42	m	64	12		
	43	m	61	14		
August 7	99	m	68	17		
	51	*	36	1.5	0	
	52	*	36	1.5	0	
	53	*	35	1.5	0	
Sept. 21	54	*	40	3	1	
	55	*	34	2	0-1[1]	

[1] probably from second clutch of season

Table 14. Phrynosoma mcallii in Plots 14, 16 and 17, Imperial and Riverside Counties, California.

Plot	Dates	Number	Sex	Snout-vent length (mm)	Weight (g)	Estimated age (months)	Reproductive condition
14	June 10-15	11	m	70	18	?	
		12	m	77	18	20	
		13	f	75	14	?	negative
16	April 16	11	m	63	-	-	
	June 7-13	12	m	75	16	21+	
		13	m	75	18	21+	
		14	f	67	14	?	
		15	m	67	15	?[1]	
17	April 20	11	m	55	-	9	
	June 20-24	12	f	73	20	21+	eggs
		13	m	71	16	21	
		14	m	68	13	?	
		15	m	74	17		
		16	m	70	16		
		17	f	70	19	21	five 4-5 mm follicles
		18	f	79	23	21+	eggs
		19	f	76	19	21	five 5-mm follicles
		21	f	65	13	?	negative

[1]just outside plot

Table 15. Captures and recaptures of marked Phrynosoma mcallii in Plot 15 during May 1978.

Dates	Time of day	New animals marked	Animals recaptured
May 7	evening	1	0
8	morning	3	0
	evening	2	0
9	morning	5	0
	evening	3	1
10	morning	1	3
15	evening	4	3
16	morning	2	10
	evening	5	7

Table 16. Analysis of May capture-recapture data for Phrynosoma mcallii in Plot 15. X_t is the number of marked individuals at risk just before the t_{th} sample, n_t the number of individuals in the t_{th} sample, and x_t the number of marked individuals in the t_{th} sample.

Dates	X_t	n_t	x_t	$x_t X_t$	$n_t X_t^2$
May 9	6	9	1	6	324
May 10-15	14	11	6	84	2156
May 16	19	24	17	323	8664
Totals				413	11144

Table 17. Estimated home ranges of 11 horned lizards (*Phrynosoma mcallii*) in Imperial County, California.

Number	Sex	n	Size of convex polygon (m^2)	Sample size correction factor	Estimated home range (ha)
11	m	6	2,112	0.171	1.24
12	f	3	45	0.043	0.10
13	m	3	804	0.043	1.87
18	m	4	934	0.092	1.02
19	f	4	487	0.092	0.53
21	f	4	1,288	0.092	1.40
24	m	7	824	0.196	0.42
25	m	4	1,763	0.092	1.92
26	f	3	51	0.043	0.12
27	f	3	214	0.043	0.50
28	f	3	17	0.043	0.04

Table 18. Numbers of *Uma notata* (Plots 10-16) and *U. inornata* (Plot 17) observed and man-hours of effort. Figures for Plot 15 include work during August 1978.

Plot	Total man-hours	Number of *Uma* observed	Number of *Uma* per man-hour
10	26.85	8	0.3
11	16.75	0	0
12	20.75	0	0
13	37.40	0	0
14	33.33	0	0
15	60.20	2	0.03
16	28.25	6	0.2
17	27.00	136	5.0
18	24.00	5	0.2

Table 19. Observations of Uma inornata in Plot 17. All animals were captured and released on June 23-25, 1978

Sex	Snout-vent length (mm)	Live body weight (g)	Reproductive condition
f	81	17	eggs
f	69	11	negative
f	73	16	two 11-12 mm yolked follicles
f	73	14	eggs
f	80	17	eggs
f	70	10	negative
f	69	10	negative
f	77	15	two 3-4 mm yolked follicles
f	71	12	small yolked follicles
f	82	20	two 7-8 mm yolked follicles
f	77	15	two 7-8 mm yolked follicles
f	73	13	eggs
f	73	14	eggs
f	77	15	
f	86	19	negative
m	113	40	
m	74	14	
m	97	29	
m	74	13	
m	86	18	
m	107	39	
m	96	30	
m	97	30	
m	112	45	
m	79	15	
m	72	13	
m	95	26	
m	87	19	
m	78	14	
m	93	25	
m	90	19	

Table 20. Capture-recapture data for Uma inornata in Plot 17, June 23-25, 1978. Symbols are as in Table 16.

Date	X_t	n_t	x_t	$x_t X_t$	$n_t X_t^2$
June 23, PM	15	8	2	30	1800
June 24, AM	21	12	6	126	5292
June 24, PM	27	9	5	135	6561
June 25, AM	31	15	10	310	14415

Table 21. Correlation matrix for indexes of abundance of *Phrynosoma mcallii* in eight plots in Imperial and Riverside Counties, California, and nine independent variables. Numbers of independent variables are given in text.

	Independent variables								
Variables	1	2	3	4	5	6	7	8	9
Lizard abundance	0.27	-0.41	0.63	0.09	0.17	0.81	-0.84	-0.12	0.37
1	-	0.10	0.35	-0.81	0.52	0.15	-0.24	-0.49	-0.59
2	-	-	0.14	-0.17	-0.11	-0.35	0.42	0.10	-0.53
3	-	-	-	-0.04	-0.14	0.33	-0.37	-0.25	-0.10
4	-	-	-	-	-0.44	0.12	0.11	0.61	0.54
5	-	-	-	-	-	0.59	-0.51	-0.52	-0.17
6	-	-	-	-	-	-	-0.93	-0.27	-0.39
7	-	-	-	-	-	-	-	0.41	-0.38
8	-	-	-	-	-	-	-	-	0.44

Table 22. Summary table for multiple regression analysis of horned lizard abundance in eight plots in Imperial and Riverside Counties, California.

Variable entered	Multiple R^2	Increase in R^2
Annual diversity	0.713	
Perennial diversity	0.832	0.119
Number of harvester ant nests	0.921	0.089
Aggregate perennial cover	0.952	0.031
Number of nests of harvester ants and *Conomyrma insana*	0.996	0.044
Cover by annuals	1.000	0.004

Table 23. Indexes of abundance of Phrynosoma mcallii in eight plots in Imperial and Riverside Counties, California, compared with values predicted by Equation 17.

Plot	Actual index of abundance	Predicted index of abundance
10	1	18.5
11	1	-4.1
12	1	8.5
13	1	0.9
14	12	21.8
15	114	112.5
16	14	-0.6
17	48	34.7

Appendix 1

Description and location of nine study areas in Imperial and Riverside Counties, California

Plot	Description	Quadrangle
10	Sandy area and microphyll woodland near Glamis (N. of Hwy 78) SW ¼ Sec. 29, NW ¼ Sec. 32, T. 13 S., R. 18 E.	Glamis 15 min.
11	Dense thickets of Larrea tridentata near Coachella Canal (N. of Hwy 78), NS ¼ Sec. 21, T. 13 S., R. 17 E.	Acolita 15 min.
12	Stand of Larrea in sandy area north of Hwy 78 (East Mesa) SE ¼ Sec. 32, T. 13 S., R. 17 E.	Glamis 15 min.
13	Stands of Prosopis on sandy hummocks, east of Highline Canal and south of Hwy 78 (East Mesa) NW ¼ Sec. 19, T. 14S., R. 17 E.	Glamis 15 min.
14	Stand of Larrea in pebbly area east of Highline Canal and south of Hwy 78 (East Mesa) NW ¼ Sec. 25, T. 14 S., R. 16 E.	Holtville N.E. 7.5 min.
15	Stand of Larrea in Yuha Basin SW ¼ Sec. 18, T. 17 S., R. 12 E.	Coyote Wells 15 min.
16	Stand of Prosopis in Borrego Desert south of Hwy 78 SW ¼ Sec. 30, T. 12 S., R. 10 E.	Harpers Well 7.5 min.
17	Stand of Larrea and Atriplex in dunes near Bermuda Dunes NE ¼ Sec. 36, T. 5 S., R. 6 E.	Thousand Palms 15 min.
18	Republic Geothermal Site, Secs. 29 and 30, T. 15 S., R. 17 E.	Holtville SE 7.5 min.

Appendix 2

Profile descriptions of type locations at Plot 10

MAPPING UNIT: Active dune sand

Mapping symbol: Du

Classification: mixed, hyperthermic Typic Torripsamment

Location: NW corner of plot

This miscellaneous land class consists of active sand dunes. No profile description was developed for a type location of this soil.

MAPPING UNIT: Rositas loamy fine sand, 2-15% slopes, dune phase

Mapping symbol: RsD

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 4844

C 0-75+cm -- Light yellowish brown (10YR 6/4) stratified loamy fine sand; single grain; loose, nonsticky, nonplastic; slightly effervescent; mildly alkaline (pH 7.7).

MAPPING UNIT: Rositas silty clay loam, 0-5% slopes

Mapping symbol: RtB

Classification: mixed, hyperthermic, Typic Torripsamment

Location: Near 7244

C1 0-5cm -- Very pale brown (10YR 7/3) stratified silty clay loam; massive; hard to very hard, sticky, plastic; strongly effervescent; moderately alkaline (pH 8.0); abrupt boundary.

C2 5-75+cm -- Light yellowish brown (10YR 6/4) loamy fine sand; single grain; loose, nonsticky, nonplastic; slightly effervescent; mildly alkaline (pH 7.6).

Profile descriptions of type locations at Plot 11

MAPPING UNIT: Glamis* gravelly silt loam, 0-2% slopes

Mapping symbol: GlA

Classification: clayey over sandy, montmorillonitic (calcareous), hyperthermic Typic Torrifluvent

Location: Near 7248

C1 0-33cm — Light yellowish brown (10YR 6/4) gravelly silt loam; weak, medium, platy structure; slightly hard, nonsticky, slightly plastic; strongly effervescent; nodules of calcium carbonate; moderately alkaline (pH 8.2); abrupt boundary.

IIC2 33-45cm — Brown (7.5YR 5/4) stratified clay; massive; hard, firm, sticky, plastic; strongly effervescent; moderately alkaline (pH 8.2); abrupt boundary.

IIIC3 45-100cm — Very pale brown (10YR 7/4) sand; single grain; loose, nonsticky, nonplastic; strongly effervescent; moderately alkaline (pH 8.3).

*This pedon is a taxadjunct to the Glamis series which is classified as a clayey over loamy, mixed, hyperthermic Typic Torrifluvent.

MAPPING UNIT: Rositas sand, 0-5% slopes

Mapping symbol: RcB

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 5444

C1 0-1cm — Sand with nodules of $CaCO_3$

C2 1-75+cm — Light yellowish brown (10YR 6/4) fine sand; single grain; loose, nonsticky, nonplastic; strongly effervescent; seam of $CaCO_3$ nodules at 43cm; moderately alkaline (pH 8.3).

Profile description of type location at Plot 12

MAPPING UNIT: Rositas fine sand, 2-15% slopes, dune phase

Mapping symbol: RfD

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 7256

C1 0-3cm — Light yellowish brown (10YR 6/4) fine sand; single grain; loose, nonsticky, nonplastic; slightly effervescent; moderately alkaline (pH 8.0); gradual boundary.

C2 3-75+cm — Light yellowish brown (10YR 6/4) sand; single grain; loose, nonsticky, nonplastic; slightly effervescent; moderately alkaline (pH 8.2).

Profile descriptions of type locations at Plot 13

MAPPING UNIT: Aco loamy fine sand, 0-30% slopes

Mapping symbol: AcE

Classification: coarse-loamy, mixed (calcareous), hyperthermic Typic Torriorthent

Location: Near 4468

C1 0-10cm— Reddish yellow (7.5YR 6/6) loamy fine sand; singly grain; soft, nonsticky, nonplastic; strongly effervescent; moderately alkaline (pH 8.0); gradual boundary.

C2 10-100cm — Reddish yellow (7.5YR 6/6) loamy fine sand; single grain; loose, nonsticky, nonplastic; strongly effervescent; moderately alkaline (pH 8.0).

MAPPING UNIT: Rositas fine sand, 2-15% slopes, dune phase

Mapping symbol: RfD

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 4444

C1 0-10cm — Very pale brown (10YR 7/4) thinly stratified fine sand; single grain; soft, nonsticky, nonplastic; not effervescent; moderately alkaline (pH 8.0); gradual boundary.

C2 10-100cm — Very pale brown (10YR 7/4) fine sand; single grain; loose, nonsticky, nonplastic; not effervescent; moderately alkaline (pH 8.0).

Appendix 6

Profile description of type location at Plot 14

MAPPING UNIT: Rositas gravelly sand, 0-2% slopes

Mapping symbol: RaA

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 4444

0-1cm — Gravelly sand (desert pavement)

C1 1-30cm — Light yellowish brown (10YR 6/4) sand; single grain; loose, nonsticky, nonplastic; slightly effervescent; moderately alkaline (pH 8.4); scattered iron stains; gradual boundary.

C2 30-75+cm — Light yellowish brown (10YR 6/4) sand; single grain; loose, nonsticky, nonplastic; slightly effervescent; moderately alkaline (pH 8.2).

Profile descriptions of type locations at Plot 15

MAPPING UNIT: Rositas loamy coarse sand, 0-5% slopes

Mapping symbol: RmB

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 7244

C1 0-5cm -- Pinkish white (7.5YR 8/2) loamy coarse sand; scattered areas of desert pavement; single grain; loose, nonsticky, nonplastic; slightly effervescent; moderately alkaline (pH 8.1); clear boundary.

C2 5-40cm -- Brownish yellow (10YR 6/6) loamy sand; single grain; loose, nonsticky, nonplastic; strongly effervescent; moderately alkaline (pH 8.1); clear boundary.

C3 40-75+cm -- Brownish yellow (10YR 6/6) loamy sand; single grain; slightly hard, nonsticky, nonplastic; strongly effervescent; segregated line; moderately alkaline (pH 8.1).

MAPPING UNIT: Rositas coarse sand, 0-2% slopes

Mapping symbol: RbA

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 4450

This soil is quite similar to RmB except that it has a coarse sand overburden that has accumulated in some areas around the vegetation.

Profile descriptions of type locations at Plot 16

MAPPING UNIT: Antho loamy sand, 2-9% slopes, eroded

Mapping symbol: AnB

Classification: coarse-loamy, mixed (calcareous), hyperthermic Typic Torrifluvent

Location: Near 6244

C1 0-10cm -- Pale brown (10YR 6/3) loamy sand; single grain; loose, nonsticky, nonplastic; strongly effervescent; moderately alkaline (pH 8.0); clear boundary.

---- C2 10-75cm -- Pale brown (10YR 6/3) heavy sandy loam. Reddish yellow (7.5YR 6/8) iron stains; massive; extremely hard, nonsticky, nonplastic; violently effervescent; moderately alkaline (pH 8.2).

MAPPING UNIT: Rositas loamy fine sand, 2-15% slopes, dune phase

Mapping symbol: RsD

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 6844

C1 0-100cm -- Light yellowish brown (10YR 6/4) stratified loamy fine sand; single grain; loose, nonsticky, nonplastic; strongly effervescent; moderately alkaline (pH 8.0).

MAPPING UNIT: Rositas loamy coarse sand, 0-5% slopes

Mapping symbol: RmB

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 7246

C1 0-10cm -- Light brown (7.5YR 6/4) thinly stratified loamy coarse sand; single grain; loose, nonsticky, nonplastic; strongly effervescent; moderately alkaline (pH 8.0); abrupt boundary.

IIC2 10-42cm -- Light gray (10YR 7/1) coarse sand; single grain; loose, nonsticky, nonplastic; slightly effervescent; moderately alkaline (pH 8.2); abrupt boundary.

IIIC3 42-100cm -- Light gray (10YR 7/2) loamy fine sand; massive; slightly hard, nonsticky, nonplastic; strongly effervescent; moderately alkaline (pH 8.2).

MAPPING UNIT: Rositas silty clay loam, 0-5% slopes

Mapping symbol: RtB

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 6472

There are some small inclusions of Rositas soils with finer textured surface layers that are due to water sorting. No type location was described but the areas were similar to RtB from plot 10.

Appendix 9

Profile descriptions for type locations at Plot 17

MAPPING UNIT: Rositas loamy sand, 2-9% slopes, dune phase

Mapping symbol: RnC

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 6844

C1 0-5cm -- Light gray (10YR 7/2) loamy sand; single grain; loose, nonsticky, nonplastic; strongly effervescent; moderately alkaline (pH 8.0); gradual boundary.

C2 5-100cm -- Light gray (10YR 7/2) sand; single grain; loose, nonsticky, nonplastic; slightly effervescent; mildly alkaline (pH 7.6).

MAPPING UNIT: Rositas loamy sand, 2-9% slopes, hard, eroded phase

Mapping symbol: RoC

Classification: mixed, hyperthermic Typic Torripsamment

Location: Near 6644.

C1 0-5cm -- Light gray (10YR 7/2) loamy sand; massive; very hard, nonsticky, nonplastic; strongly effervescent; moderately alkaline (pH 8.0); clear boundary. (5-10cm thick)

C2 5-35cm -- Light gray (10YR 7/2) sand; single grain; slightly hard, nonsticky, nonplastic; slightly effervescent; mildly alkaline (pH 7.4); gradual boundary.

C3 35-100cm -- Light gray (10YR 7/2) loamy sand; single grain; slightly hard, nonsticky, nonplastic; slightly effervescent; mildly alkaline (pH 7.6).

MAPPING UNIT: Rositas loamy sand, dune and eroded complex

Mapping symbol: Rn-Ro

This mapping unit consists of loose sand in dune areas and sands with a very hard consistence in the washes and eroded areas. Because of the intermingling of the soils the area was mapped as a complex.

APPENDIX 10

ESTIMATES OF DENSITY, FREQUENCY AND COVERAGE OF PERENNIAL PLANTS RECORDED IN IRTEEN 50 X 4 METER QUADRATS IN PLOT 10. IMPORTANCE VALUE INDEXES HAVE BEEN COMPUTED THE SUMS OF RELATIVE DENSITIES, FREQUENCIES AND COVERAGE FOR EACH SPECIES.

PECIES CODE	NUMBER COUNTED	DENSITY (N/HA)	AVERAGE COVERAGE SINGLE PLANT (M SQ)	COVERAGE (PERCENT)	FREQUENCY (PERCENT)	RELATIVE DENSITY (PERCENT)	RELATIVE COVER (PERCENT)	RELATIVE FREQUENCY (PERCENT)	IMPORTANCE VALUE INDEX
ER FLO	129	289.77	13.09	37.93	100	28.50	83.89	24.53	136.91
TI LIN	155	534.31	.31	1.68	92	52.54	3.72	22.64	78.91
AR TRI	17	36.13	7.12	2.57	92	3.55	5.69	22.64	31.89
MB DUM	25	90.99	.13	.12	38	8.95	.27	9.43	18.65
YM SAL	14	43.77	.76	.33	46	4.30	.73	11.32	16.36
HI LIN	2	10.38	20.49	2.13	15	1.02	4.70	3.77	9.50
AL MOL	2	7.69	.41	.03	15	.76	.07	3.77	4.60
OR GLO	1	3.85	10.81	.42	7	.38	.92	1.89	3.18

APPENDIX 11

ESTIMATES OF DENSITY, FREQUENCY AND COVERAGE OF PERENNIAL PLANTS RECORDED IN TRTEEN 50 X 4 METER QUADRATS IN PLOT 11. IMPORTANCE VALUE INDEXES HAVE BEEN COMPUTED THE SUMS OF RELATIVE DENSITIES, FREQUENCIES AND COVERAGE FOR EACH SPECIES.

ECIES ODE	NUMBER COUNTED	DENSITY (N/HA)	AVERAGE COVERAGE SINGLE PLANT (M SQ)	COVERAGE (PERCENT)	FREQUENCY (PERCENT)	RELATIVE DENSITY (PERCENT)	RELATIVE COVER (PERCENT)	RELATIVE FREQUENCY (PERCENT)	IMPORTANCE VALUE INDEX
R TRI	30	62.79	8.14	5.11	69	34.92	58.27	39.13	132.32
B DUM	31	98.91	.52	.52	69	55.00	5.89	39.13	100.02
H TRI	11	18.13	17.33	3.14	38	10.08	35.84	21.74	67.66

APPENDIX 12

ESTIMATES OF DENSITY, FREQUENCY AND COVERAGE OF PERENNIAL PLANTS RECORDED IN IRTEEN 50 X 4 METER QUADRATS IN PLOT 12. IMPORTANCE VALUE INDEXES HAVE BEEN COMPUTED S THE SUMS OF RELATIVE DENSITIES, FREQUENCIES AND COVERAGE FOR EACH SPECIES.

PECIES CODE	NUMBER COUNTED	DENSITY (N/HA)	AVERAGE COVERAGE SINGLE PLANT (M SQ)	COVERAGE (PERCENT)	FREQUENCY (PERCENT)	RELATIVE DENSITY (PERCENT)	RELATIVE COVER (PERCENT)	RELATIVE FREQUENCY (PERCENT)	IMPORTANCE VALUE INDEX
AR TRI	63	131.89	7.96	10.50	92	71.91	83.05	70.59	225.55
NB DUN	20	51.53	4.16	2.14	38	28.09	16.95	29.41	74.45

APPENDIX 13

ESTIMATES OF DENSITY, FREQUENCY AND COVERAGE OF PERENNIAL PLANTS RECORDED IN THIRTEEN 50 X 4 METER QUADRATS IN PLOT 13. IMPORTANCE VALUE INDEXES HAVE BEEN COMPUTED AS THE SUMS OF RELATIVE DENSITIES, FREQUENCIES AND COVERAGE FOR EACH SPECIES.

SPECIES CODE	NUMBER COUNTED	DENSITY (N/HA)	AVERAGE COVERAGE SINGLE PLANT (M SQ)	COVERAGE (PERCENT)	FREQUENCY (PERCENT)	RELATIVE DENSITY (PERCENT)	RELATIVE COVER (PERCENT)	RELATIVE FREQUENCY (PERCENT)	IMPORTANCE VALUE INDEX
LAR TRI	110	234.29	7.61	17.82	100	79.61	61.07	48.15	188.82
PRO GLA	33	52.33	21.54	11.27	100	17.78	38.64	49.15	104.57
AMB DUM	2	7.69	1.11	.09	7	2.61	.29	3.70	6.61

APPENDIX 14

ESTIMATES OF DENSITY, FREQUENCY AND COVERAGE OF PERENNIAL PLANTS RECORDED IN IRTEEN 50 X 4 METER QUADRATS IN PLOT 14. IMPORTANCE VALUE INDEXES HAVE BEEN COMPUTED THE SUMS OF RELATIVE DENSITIES, FREQUENCIES AND COVERAGE FOR EACH SPECIES.

ECIES ODE	NUMBER COUNTED	DENSITY (N/HA)	AVERAGE COVERAGE SINGLE PLANT (M SQ)	COVERAGE (PERCENT)	FREQUENCY (PERCENT)	RELATIVE DENSITY (PERCENT)	RELATIVE COVER (PERCENT)	RELATIVE FREQUENCY (PERCENT)	IMPORTANCE VALUE INDEX
R TRI	26	61.38	5.57	3.42	69	22.53	78.82	39.13	140.48
B QUM	59	197.19	.34	.68	84	72.38	15.56	47.83	135.77
R CAN	5	13.97	1.76	.24	23	5.09	5.61	13.04	23.75

APPENDIX 15

ESTIMATES OF DENSITY, FREQUENCY AND COVERAGE OF PERENNIAL PLANTS RECORDED IN THIRTEEN 50 X 4 METER QUADRATS IN PLOT 15. IMPORTANCE VALUE INDEXES HAVE BEEN COMPUTED AS THE SUMS OF RELATIVE DENSITIES, FREQUENCIES AND COVERAGE FOR EACH SPECIES.

SPECIES CODE	NUMBER COUNTED	DENSITY (N/HA)	AVERAGE COVERAGE SINGLE PLANT (M SQ)	COVERAGE (PERCENT)	FREQUENCY (PERCENT)	RELATIVE DENSITY (PERCENT)	RELATIVE COVER (PERCENT)	RELATIVE FREQUENCY (PERCENT)	IMPORTANCE VALUE INDEX
AMB DUM	117	373.72	.57	2.13	84	31.06	32.79	25.58	89.44
BAL EMO	110	334.82	.77	2.59	69	27.83	39.96	20.93	88.72
BAR TRI	117	401.33	.33	1.34	100	33.36	20.67	30.23	84.26
COL PAL	23	72.43	.55	.40	38	6.02	6.11	11.63	23.76
HYM SAL	6	20.72	.15	.03	38	1.72	.47	11.63	13.82

APPENDIX 16

ESTIMATES OF DENSITY, FREQUENCY AND COVERAGE OF PERENNIAL PLANTS RECORDED IN HIRTEEN 50 X 4 METER QUADRATS IN PLOT 16. IMPORTANCE VALUE INDEXES HAVE BEEN COMPUTED S THE SUMS OF RELATIVE DENSITIES, FREQUENCIES AND COVERAGE FOR EACH SPECIES.

SPECIES CODE	NUMBER COUNTED	DENSITY (N/HA)	AVERAGE COVERAGE SINGLE PLANT (M SQ)	COVERAGE (PERCENT)	FREQUENCY (PERCENT)	RELATIVE DENSITY (PERCENT)	RELATIVE COVER (PERCENT)	RELATIVE FREQUENCY (PERCENT)	IMPORTANCE VALUE INDEX
AR TRI	98	294.05	1.70	5.01	100	51.11	49.23	41.94	142.28
TR CAN	77	245.74	.70	1.73	100	42.71	17.04	41.94	101.68
RO GLA	14	27.84	12.30	3.43	23	4.84	33.69	9.68	48.21
MB DUM	2	7.69	.05	.00	15	1.34	.04	6.45	7.83

APPENDIX 17

ESTIMATES OF DENSITY, FREQUENCY AND COVERAGE OF PERENNIAL PLANTS RECORDED IN THIRTEEN 50 X 4 METER QUADRATS IN PLOT 17. IMPORTANCE VALUE INDEXES HAVE BEEN COMPUTED AS THE SUMS OF RELATIVE DENSITIES, FREQUENCIES AND COVERAGE FOR EACH SPECIES.

SPECIES CODE	NUMBER COUNTED	DENSITY (N/HA)	AVERAGE COVERAGE SINGLE PLANT (M SQ)	COVERAGE (PERCENT)	FREQUENCY (PERCENT)	RELATIVE DENSITY (PERCENT)	RELATIVE COVER (PERCENT)	RELATIVE FREQUENCY (PERCENT)	IMPORTANCE VALUE INDEX
TR CAN	70	204.27	1.70	3.46	84	64.80	47.19	33.33	145.32
AR TRI	17	33.52	9.51	3.19	84	10.63	43.43	33.33	87.40
AO WIG	15	50.51	1.13	.57	30	16.02	7.78	12.12	35.92
AI EMO	3	11.54	.91	.11	23	3.66	1.44	9.09	14.19
AM BAM	2	7.69	.15	.01	15	2.44	.16	6.06	8.66
MB DUM	2	7.69	.00	.00	15	2.44	.00	6.06	8.51

Appendix 18

Estimated densities of annual plants in Plot 10

Species	Estimated cover	Estimated density (n/m^2)
Amsinckia intermedia		0.80
Baileya pauciradiata		0.32
B. pleniradiata		0.04
Brandega bigelovii		0.92
Brassica tournefortii	3	4.88
Camissonia claviformis		0.08
Cryptantha costata		0.24
C. micrantha		0.08
Lepidium lasiocarpum		0.04
Oenothera deltoides		0.24
Oligomeris linifolia		0.08
Plantago insularis		0.40
Schismus arabicus		4.92
Sonchus oleraceus		0.08
Sphaeralcea sp.		0.08

Appendix 19

Estimated densities of annual plants in Plot 11

Species	Estimated cover	Estimated density (n/m^2)
Achyronychia cooperi		0.76
Aristida californica		0.16
Camissonia claviformis		14.32
Chorizanthe rigida		0.48
Coldenia plicata		2.36
Cryptantha angustifolia		11.48
C. micrantha		0.52
Dalea mollis		0.16
Eriogonum thomasii		0.52
Geraea canescens		0.16
Hesperocallis undulata		0.04
Langloisia schottii		1.96
Mentzelia albicaulis		0.08
Oligomeris linifolia		2.28
Palafoxia linearis		0.04
Pectocarya heterocarpa		1.96
Plantago insularis[1]	2	66.10
Schismus arabicus[1]	2	31.50
Sonchus oleraceus		0.12

[1] quadrat size of $0.1m^2$

Appendix 20

Estimated densities of annual plants in Plot 12

Species	Estimated cover	Estimated density (n/m^2)
Abronia villosa		0.12
Achyronychia cooperi		5.96
Aristida californica	3	15.08
Baileya pauciradiata		0.12
Bouteloua aristidoides		0.44
Brassica tournefortii		0.08
Camissonia claviformis		15.04
Chorizanthe brevicornu		0.08
Chorizanthe sp.		0.04
Coldenia plicata		0.04
Cryptantha angustifolia[1]	2	145.60
C. micrantha		8.88
Dithyrea californica		2.68
Langloisia schottii		0.48
Mentzelia albicaulis		0.44
Oenothera deltoides		1.60
Palafoxia linearis		0.16
Pectocarya heterocarpa		6.04
Plantago insularis[1]	3	256.00
Schismus arabicus[1]	2	55.60
Sonchus oleraceus		0.16

[1]Quadrat size of 0.1 m^2

Appendix 21

Estimated densities of annual plants in Plot 13

Species	Estimated cover	Estimated density (n/m^2)
Abronia villosa		0.16
Achyronychia cooperi		7.84
Baileya pauciradiata		0.08
Camissonia claviformis		2.64
Caulanthus cooperi		0.12
C. lasiophyllus		0.04
Cryptantha angustifolia[1]	3	60.00
C. micrantha		6.00
Dalea mollis		0.12
Dithyrea californica		0.20
Lepidium lasiocarpum		1.60
Nicotiana clevelandii		0.16
Oligomeris linifolia	2	5.04
Pectocarya heterocarpa		0.72
Phacelia pediculoides		7.12
Plantago insularis		0.44
Schismus arabicus[1]	2	24.80
Streptanthella longirostris		3.12

[1]quadrat size of 0.1 m^2

Appendix 22

Estimated densities of annual plants in Plot 14

Species	Estimated cover	Estimated density (n/m^2)
Achyronychia cooperi		1.92
Aristida californica		1.76
Camissonia claviformis		13.52
Cryptantha angustifolia	3	110.68
C. micrantha		3.52
Dithyrea californica		0.08
Eriogonum thomasii		1.40
Langloisia schottii		0.56
Mentzelia albicaulis		0.12
Oligomeris linifolia	2	7.52
Palafoxia linearis		0.16
Pectocarya heterocarpa		0.56
Plantago insularis		2.96
Schismus arabicus		19.68
Sonchus oleraceus		0.04

Appendix 23

Estimated densities of annual plants in Plot 15

Species	Estimated cover	Estimated density (n/m^2)
Achyronychia cooperi		0.08
Aristida californica		0.08
Baileya pauciradiata		0.28
Camissonia boothii		0.08
C. claviformis		6.12
Chaenactis stevioides		0.12
Cryptantha angustifolia		1.68
C. costata		1.16
Dalea mollis		0.20
Eriogonum thomasii		1.40
Geraea canescens		0.84
Langloisia schottii		1.56
Mentzelia albicaulis		0.52
Nama demissum		0.04
Plantago insularis[1]	3	1311.40
Schismus arabicus		0.04
Stillingia spinulosa		0.12

[1] quadrat size of 0.1 m^2

Appendix 24

Estimated densities of annual plants in Plot 16

Species	Estimated cover	Estimated density (n/m^2)
Abronia villosa		0.08
Astragalus aridus		0.20
Baileya pauciradiata		0.28
Camissonia claviformis		3.36
Cryptantha angustifolia		0.04
C. costata	2	47.12
Oenothera deltoides		0.08
Oligomeris linifolia	2	26.84
Plantago insularis		9.60
Sphaeralcea orcuttii	3	6.68

Appendix 25

Estimated densities of annual plants in Plot 17

Species	Estimated density (n/m^2)
Abronia villosa	0.04
Achyronychia cooperi	0.40
Astragalus aridus	0.04
A. didymocarpus	0.04
Baileya pauciradiata	1.04
Camissonia boothii	0.20
C. claviformis	19.80
Chorizanthe brevicornu	0.08
Cryptantha angustifolia	2.96
Dicoria canescens	0.16
Eriogonum thomasii	0.16
Erodium cicutarium	0.04
Geraea canescens	0.24
Langloisia schottii	1.84
Nama demissum	0.04
Oenothera deltoides	1.84
Palafoxia linearis	7.04
Perityle emoryi	0.12
Phacelia crenulata	0.04
Plantago insularis	0.44
Salsola sp.	0.12
Schismus barbatus	10.28

Appendix 26

Locations of Phrynosoma mcallii captured more than once in Plot 15, May-September 1978

Number	Sex	Dates	Coordinates	Distances between loci (m)
1511	m	May 7	56.6 x 51.0	
		16	55.8 x 51.7	8.0
		16	58.6 x 50.0	24.6
		June 26	53.0 x 46.0	51.6
		Aug. 7	55.0 x 45.0	16.8
		Sept. 21	65.0 x 52.6	91.6
1512	f	May 8	45.0 x 61.8	
		16	47.0 x 61.3	15.5
		June 26	45.0 x 61.0	15.2
1513	m	May 8	66.0 x 63.1	
		9	66.9 x 52.3	81.3
		16	68.4 x 66.1	104.1
1515	f	May 8	65.8 x 49.0	
		Aug. 7	68.9 x 47.0	27.7
1516	m	May 8	67.3 x 47.2	
		16	66.0 x 48.0	11.5
1518	m	May 9	48.5 x 71.1	
		10	45.0 x 67.3	38.8
		16	44.4 x 71.4	31.1
		Aug. 6	50.0 x 68.0	49.1
1519	f	May 9	62.0 x 66.4	
		16	66.3 x 63.5	38.9
		16	68.4 x 66.1	25.1
1521	f	May 9	50.4 x 71.8	
		15	47.8 x 63.0	68.8
		16	48.0 x 63.1	1.7
		Sept. 21	53.0 x 63.0	37.5
1523	f	May 9	66.9 x 52.3	
		15	67.0 x 52.4	1.1

Appendix 26 (Continued)

Number	Sex	Dates	Coordinates	Distances between loci (m)
1524	m	May 8	66.9 x 52.3	
		10	66.8 x 52.4	1.1
		15	67.0 x 52.4	1.5
		16	66.8 x 52.1	2.7
		16	66.9 x 58.0	44.3
		June 26	68.0 x 60.0	17.1
		Aug. 6	71.0 x 61.0	22.5
1525	m	May 10	67.0 x 67.4	
		16	68.5 x 61.9	42.8
		16	62.0 x 66.8	61.1
		Sept. 21	68.0 x 57.0	86.2
1526	f	May 15	46.2 x 44.0	
		16	47.0 x 45.0	9.6
		Aug. 7	56.0 x 54.0	95.5
1527	f	May 15	46.0 x 65.6	
		16	45.8 x 63.3	17.3
		16	48.8 x 60.0	33.4
1528	f	May 15	45.0 x 50.0	
		16	45.0 x 50.3	2.3
		June 27	47.0 x 56.0	45.3
1529	m	May 15	44.2 x 46.4	
		June 22	51.0 x 44.0	54.1
1536	f	May 16	62.0 x 58.0	
		June 26	58.0 x 61.0	37.5

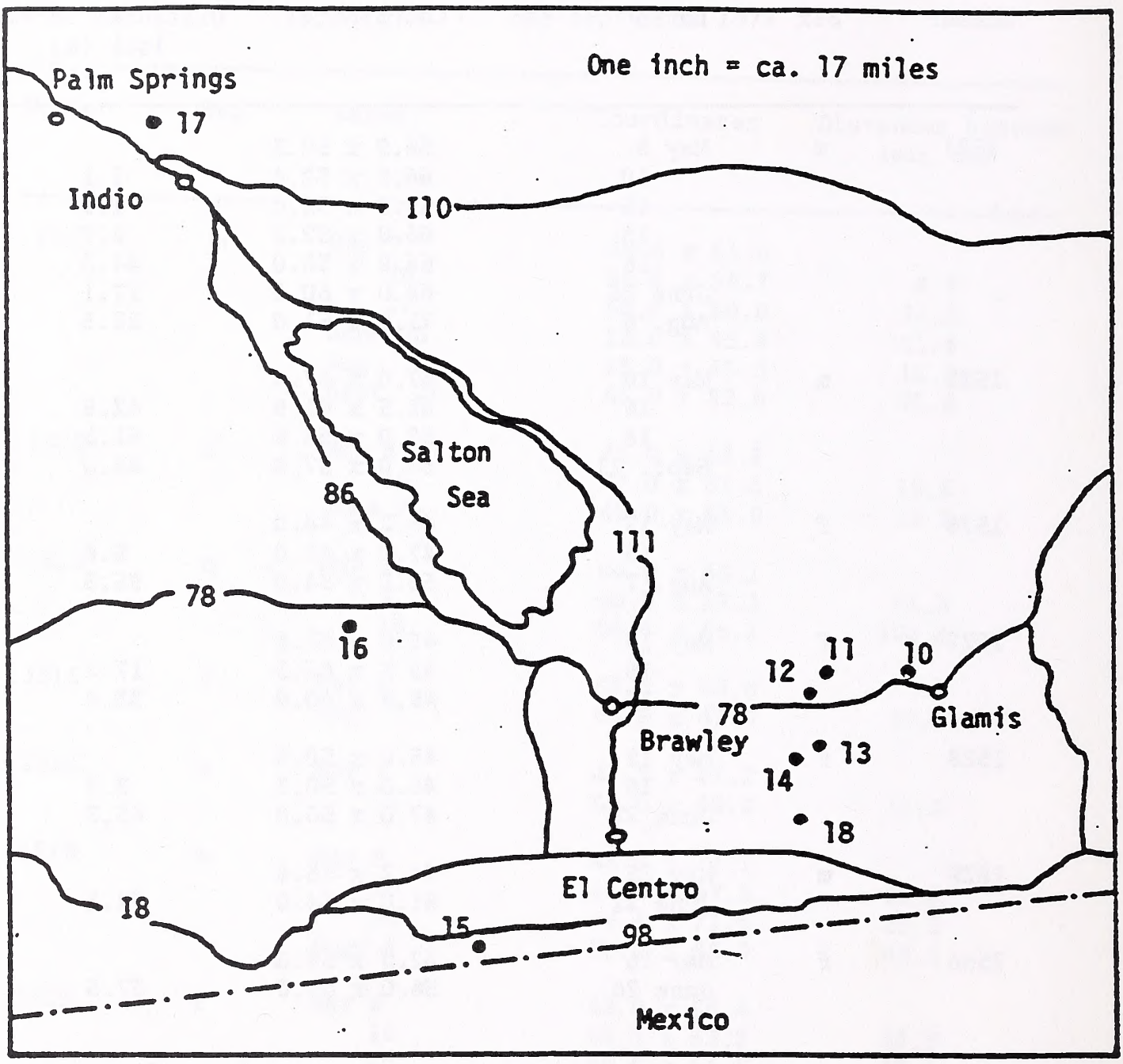

Fig. 1. Locations of nine study areas in Imperial and Riverside Counties, California.

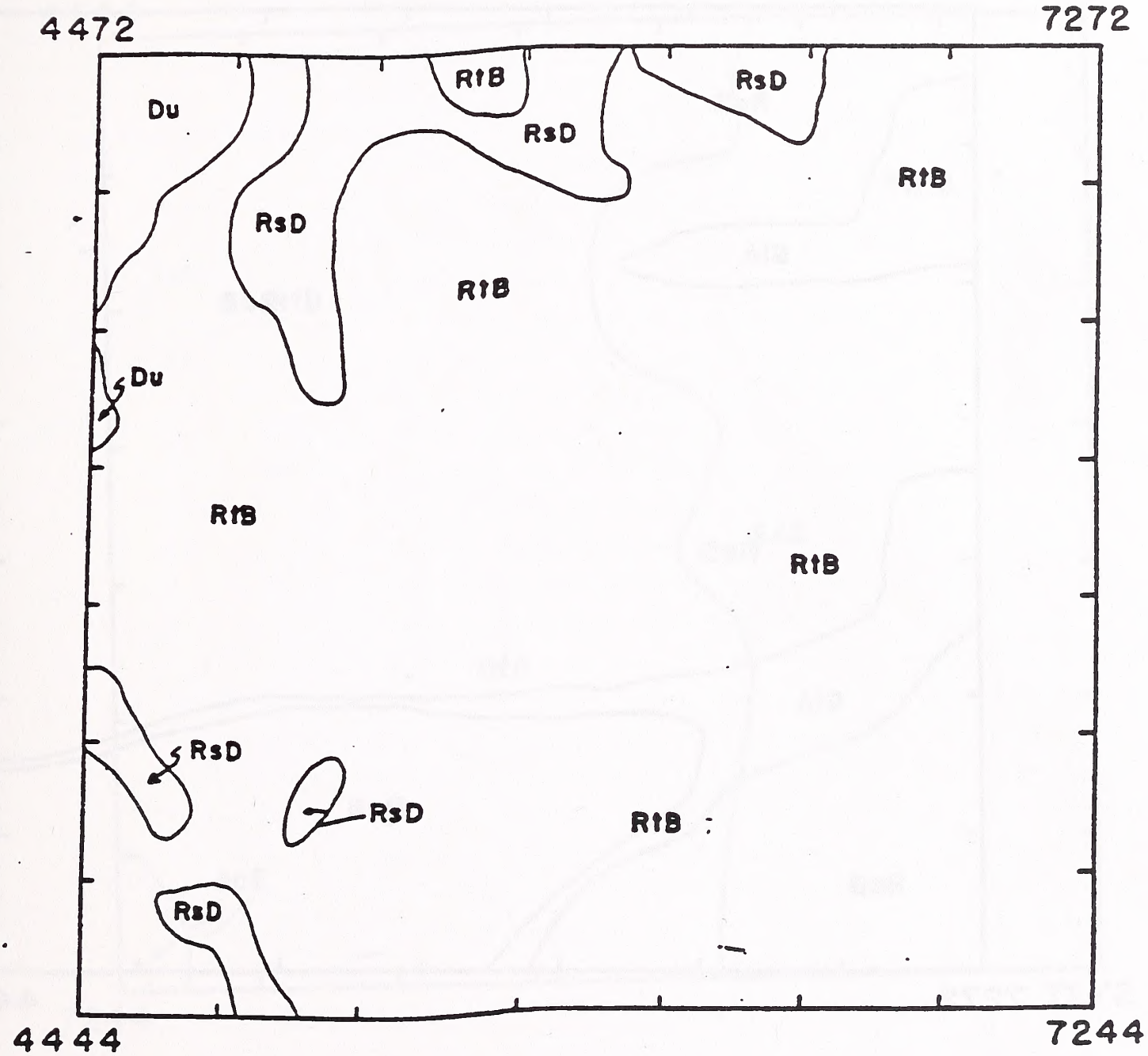

Fig. 10. Soil map of Plot 16. Mapping units are as defined in Table 2.

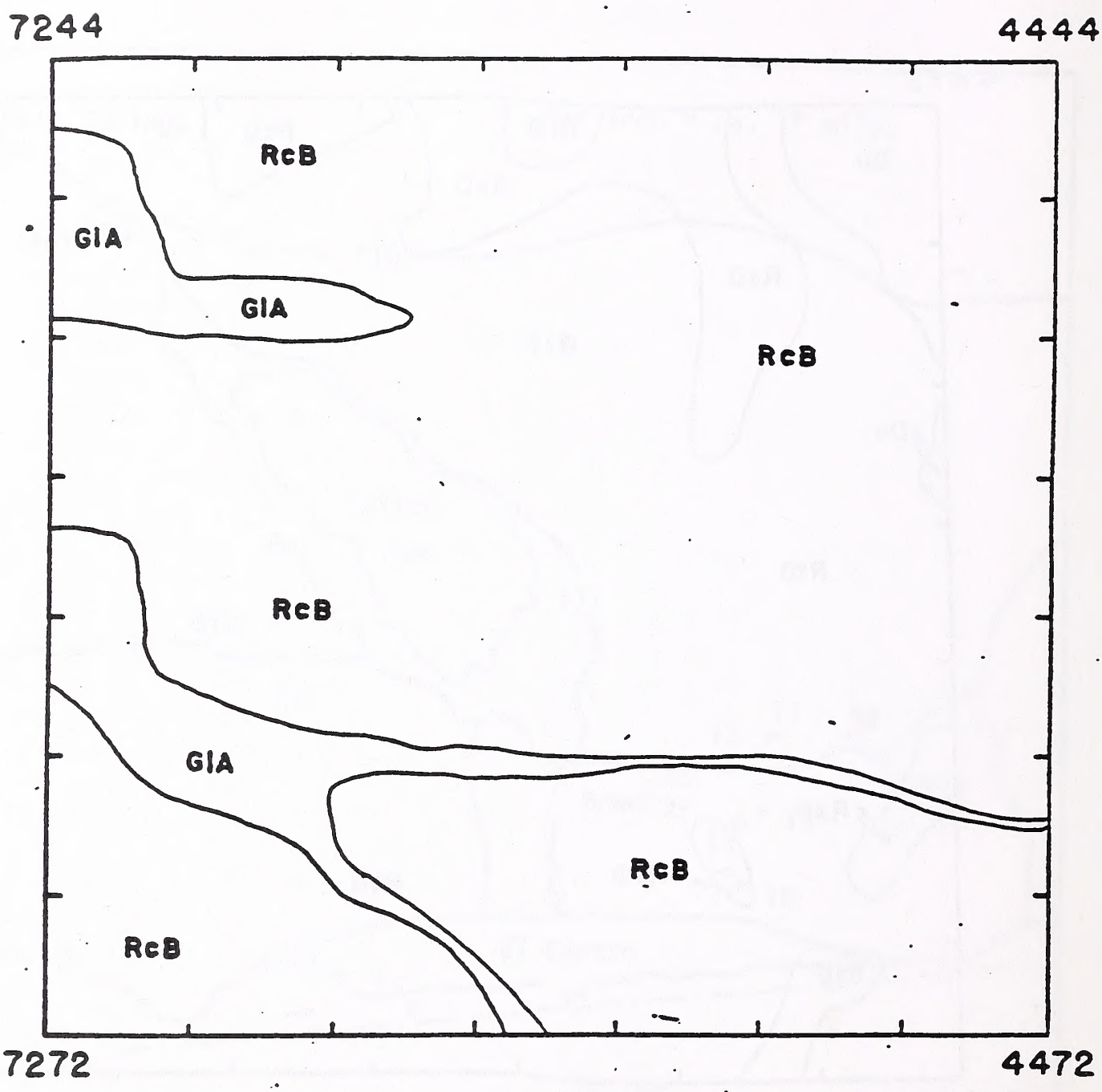

Fig. 11. Soil map of Plot 11. Mapping units are as defined in Table 2.

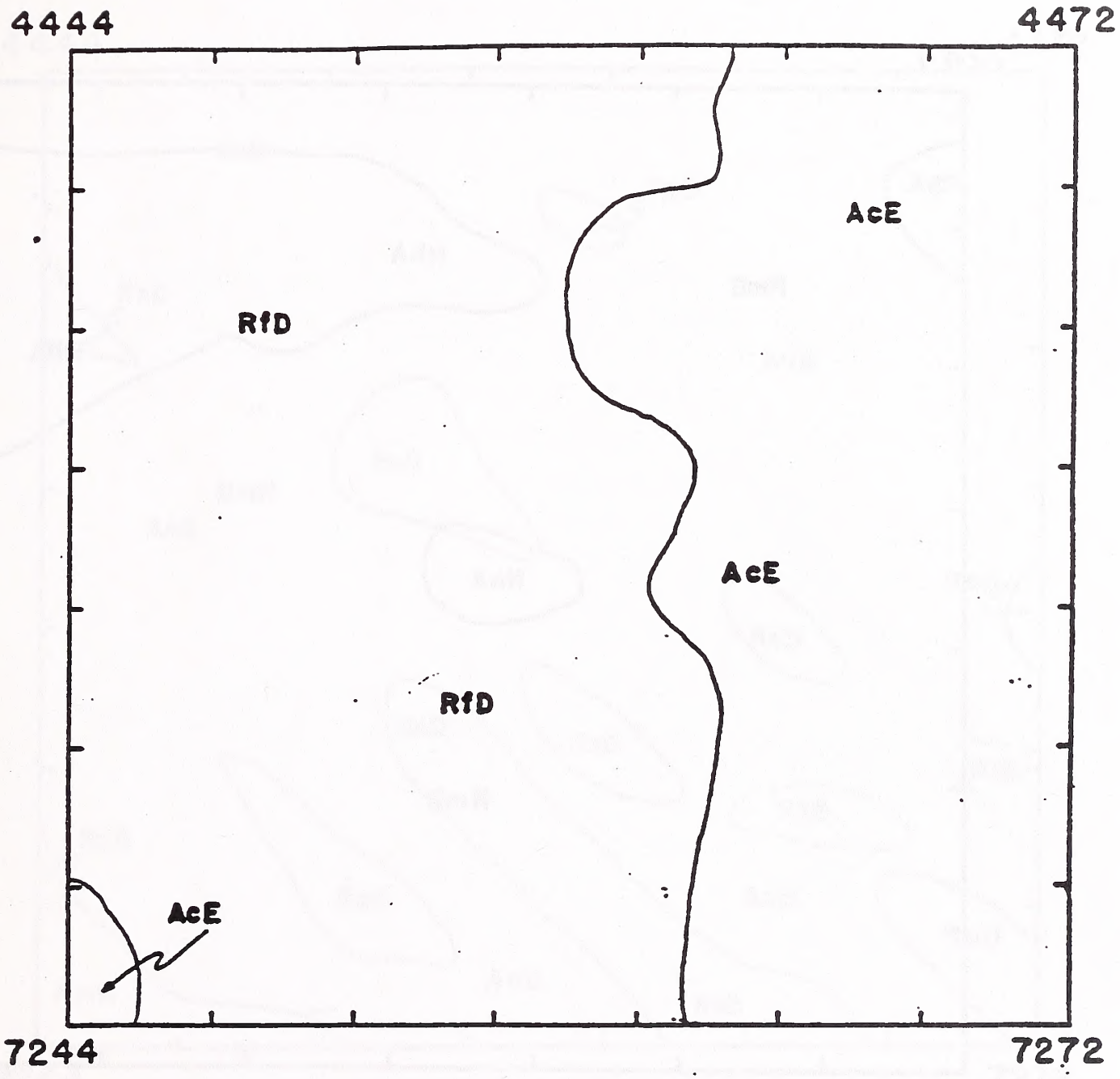

Fig. 12. Soil map of Plot 13. Mapping units are as defined in Table 2.

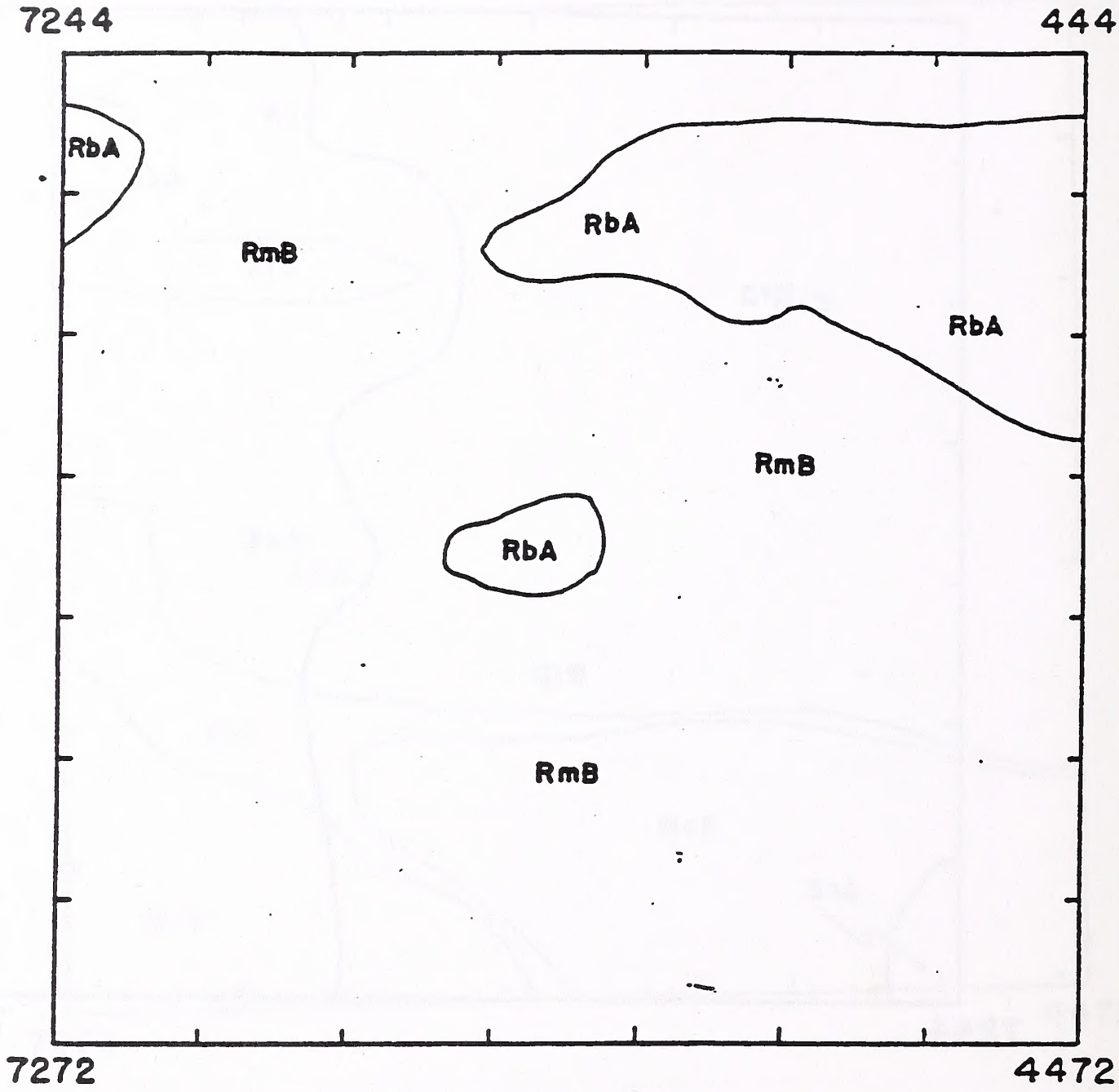

Fig. 13. Soil map of Plot 15. Mapping units are as defined in Table 2.

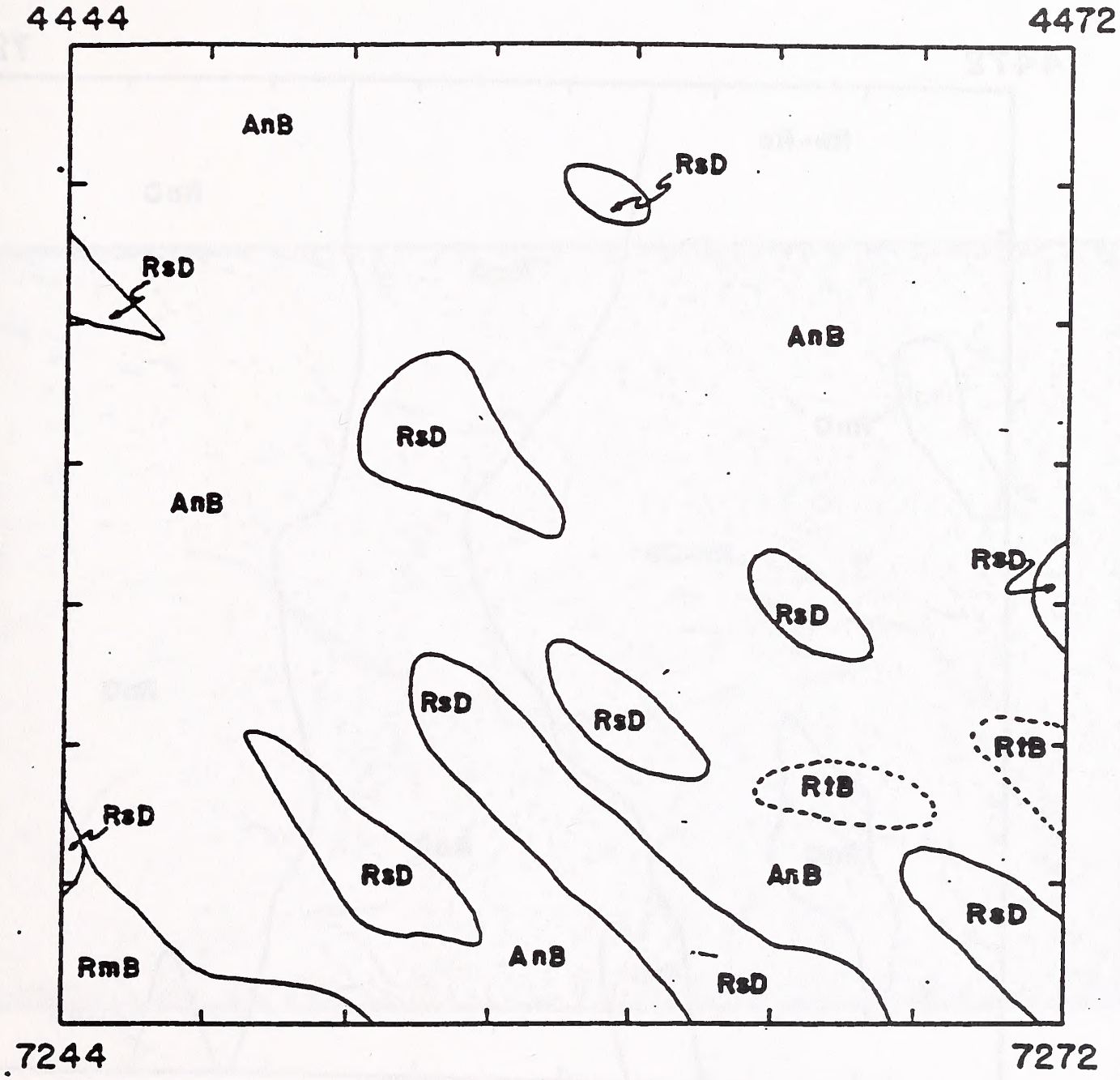

Fig. 14. Soil map of Plot 16. Mapping units are as defined in Table 2.

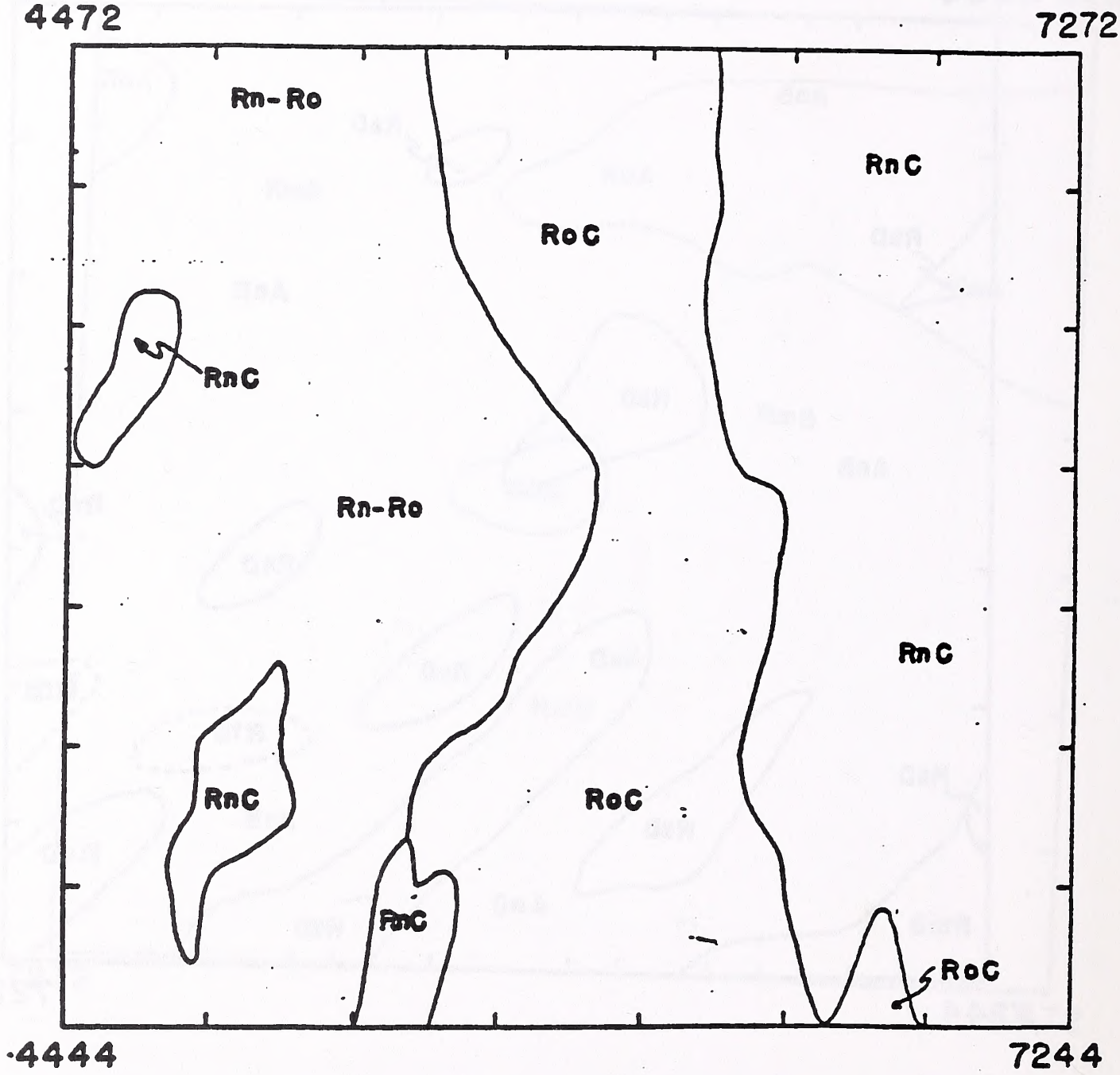

Fig. 15. Soil map of Plot 17. Mapping units are as defined in Table 2.

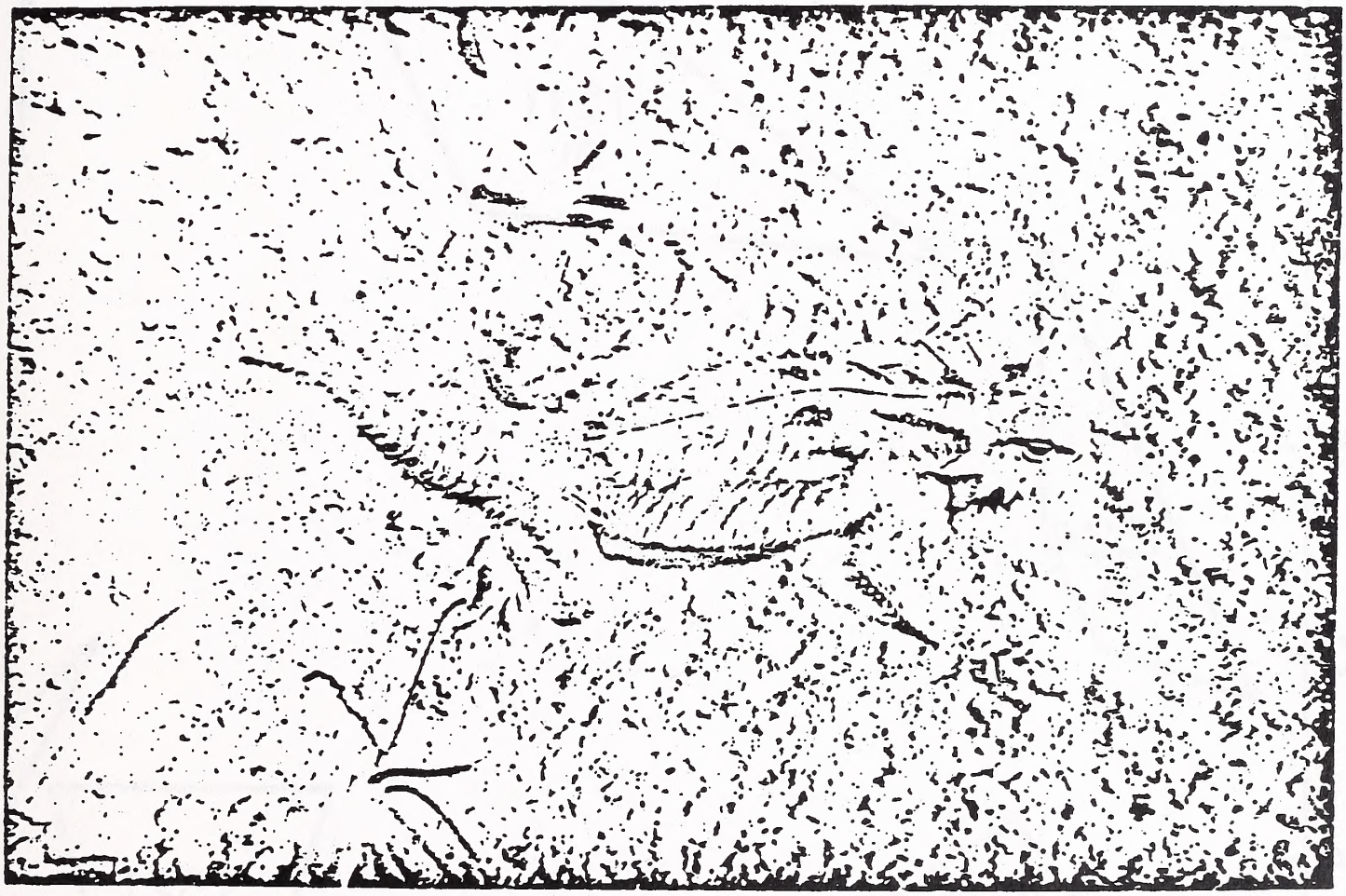

Fig. 16. Flat-tailed horned lizard (Phrynosoma mcallii)

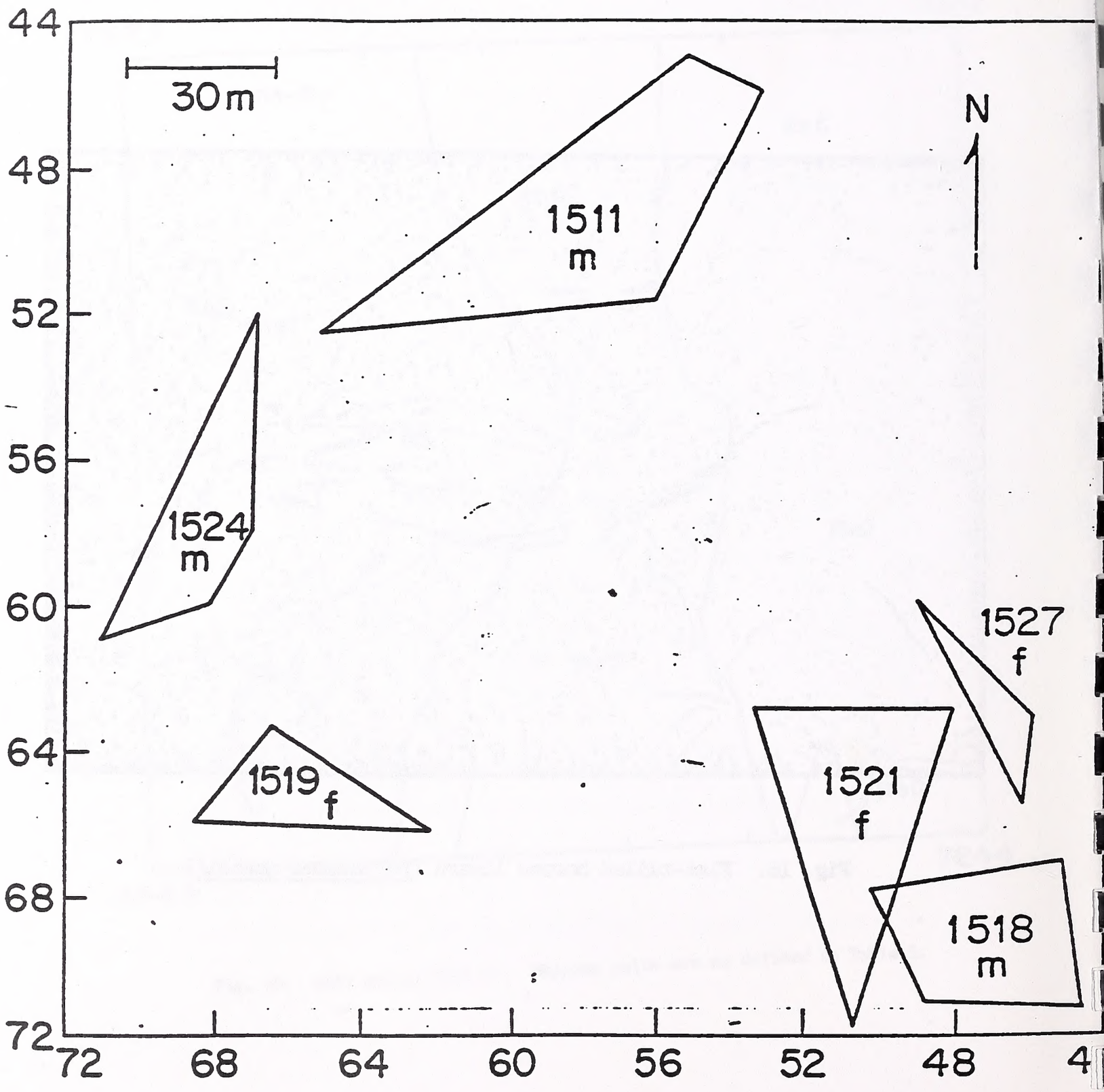

Fig. 17. Estimated home ranges (convex polygons) of six Phrynosoma mcallii in Plot 15, Imperial County, California